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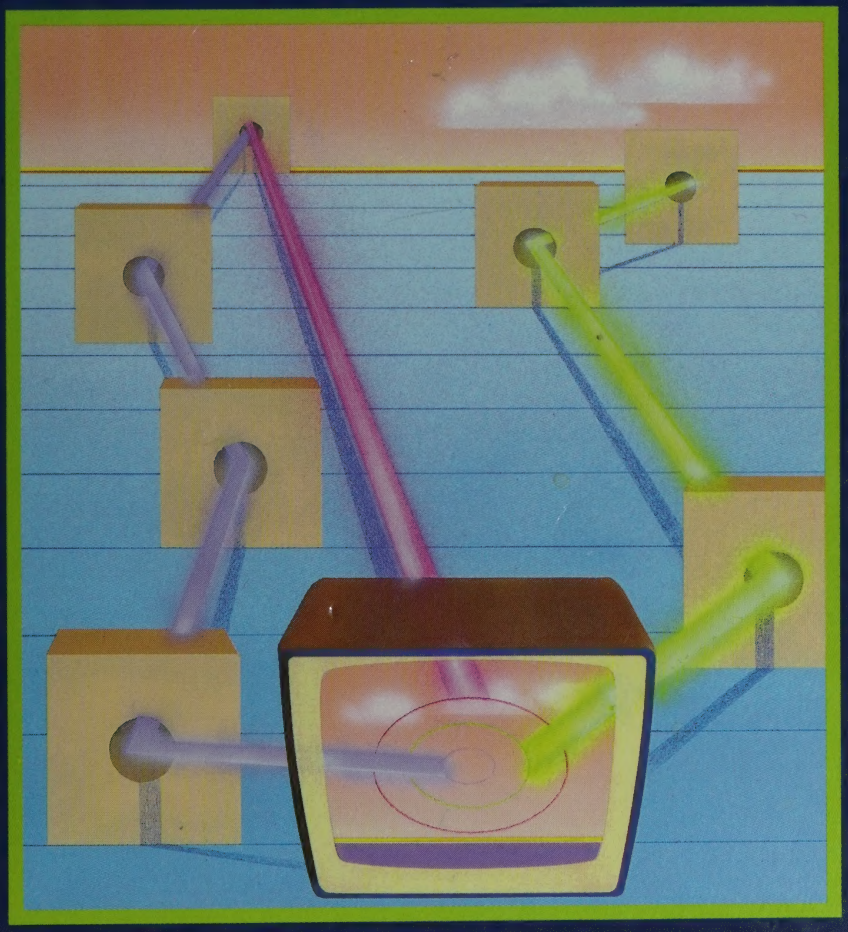
Mastering Packet Radio
The Hands-On Guide

Dave Ingram, K4TWJ



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Preface

Packet radio is the newest and, for many reasons that we'll discuss in this book, possibly the most exciting form of radiocommunications available today. It is amateur (ham) radio with a few new technological twists that enable it to operate much more efficiently—it's a way to communicate that's quicker and virtually error-free. What's more, a station is relatively simple to set up and operate, and is easily interfaced with a home computer system. Any amateur radio operator holding an FCC License can participate.

Packet radio differs from other forms of radio communications in the way it organizes and transmits information. A "packet" refers to a block of data that is compiled as a single unit and encoded with information that routes it to a particular station and also checks for errors in the transmission. Once the "packet" has been compiled, it is then transmitted in a quick burst.

The whole operation is so efficient that packet radio has become especially appealing to many home computer enthusiasts who are interested in long distance communications and are looking for an alternative to their modem and phone line. Packet radio presents so many obvious advantages that it's no surprise its popularity is growing rapidly. And this easy-to-understand book is your complete guide for getting started in this fascinating area of radiocommunications.

The basic format of this text is similar to my numerous published articles and books that many of you have read and favorably acknowledged. That is, it's maintained on a "what it is, what it does, and how I can use it" rather than a "complex technical/designer" level. As usual, however, I've included a few mild technical details along the way to continue expanding your knowledge of technology and kindle your creative thinking. It bears a reflection to the Golden Age of Radio modern style, and I think you'll like it. Packeting is tremendous fun. Come on in and join the action!

The first two chapters of this book explain packet radio in a "ground floor" manner, highlighting all the basic facts. A "tour" of my own packet setup is included, along with explanations of the setup's "whys and hows." Chapter 3 explains the internal workings of packet radio in simplified form.

Chapters 4 through 10 include every imaginable detail you need for joining the packet revolution—from equipment selection and station assembly through on-the-air operation either on the local level or worldwide. The information on networks, bulletin board systems, and satellites (such as our new JO-12 with "flying mailbox" capabilities) is right up to date, and Chapter 11 previews attractions of the times ahead. But please understand that packet radio is today's most rapidly expanding area of amateur communications, and it is evolving daily. Trying to document such accelerating and snowballing concepts calls for "stopping the action and shooting a brief picture" to establish a starting point for study.

Preparing a book of this nature isn't a simple undertaking and obviously calls for notable assistance. I would thus like to thank the following individuals and companies for the information they provided: Advanced Electronic Applications of Lynnwood, Washington, and its president, Mike Lamb, K7CAZ; Amateur Wholesale Electronics of Miami, Florida; *CTM Magazine* and publisher Chet Lambert, W4WDR; GLB Electronics; Kantronics; MFJ Enterprises; The Hamilton Area Packet Network Group (Canada); Newsome Electronics; and my faithful *CQ Magazine* readers who stood by my eclectic column during this book's writing. Finally, a special thanks to XYL Sandy, WB4OEE, for continually braving the alien perils of our new computer to type this manuscript. Over 90 pages were "lost" and reinput along the way, disk drives whirred almost continuously, format codes were ignored, and the printer went zonkers. Somehow she survived . . . I think. Maybe it was that encouraging advertisement stating modern computers make life easier(?).

Dave Ingram, K4TWJ

The Packet Radio Revolution

Packet radio is one of today's most exciting and fastest growing modes of amateur radio communications, and its unique operating capabilities are almost endless. An exceptional electronics or computer programming background isn't necessary to get involved in this communication activity; packet radio is open to all radio amateurs holding a Technician or higher class license, plus Enhanced Novices using 220 MHz. Packet radio capabilities are easily added to one's existing VHF or HF setup, plus its operational or software designs are ideally suited to both present and future times. These examples of the medium's flexibility demonstrate why packet's popularity continues spreading like wildfire in the amateur radio community. Packet is an activity that can be enjoyed in almost any "restrictive" situation or any time one desires. It's equally suited for engaging in daily amateur activities, station-to-station communications, and emergency operations, as well as passing bulletins among special interest groups, or even exchanging computer printouts. The "VHF side" of packet radio opens a complete new world of both local and long distance operating enjoyment to amateurs living in areas restricting large outdoor antennas. Likewise, packet radio's "HF side" brings all the benefits and glamor of modern computerized communications to amateurs residing in urban areas. Packet radio is indeed a fascinating pursuit, and this book is your guide to joining this new activity. Check out our sample systems shown in Figures 1-1 and 1-2.

Originally created as an amateur radio form of communications connecting one data terminal to another, packet radio continues expanding into a "Hands Across America" design using VHF, HF, and OSCAR satellite interlinks. As more and more amateurs join the "packet revolution," every gap within its massive network is being filled and provided with packet capabilities. Assuming packet radio's growth continues, we'll soon realize national and international communications capabilities that are available at

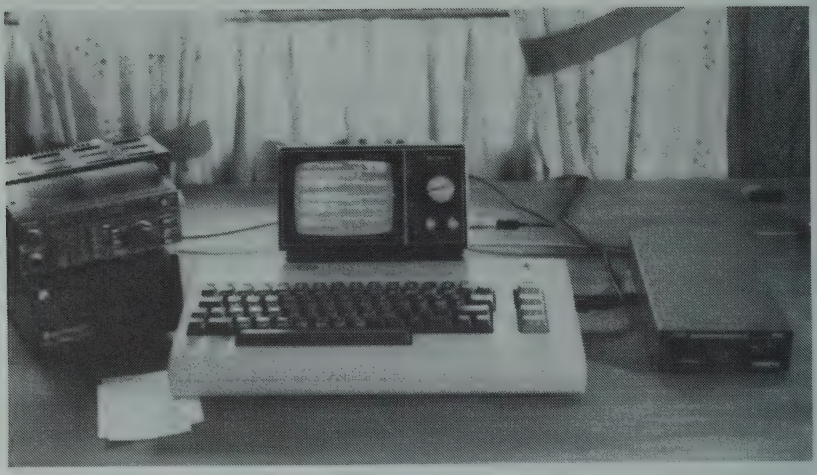

Figure 1-1. A packet radio system setup using a Commodore 64 Computer, AEA "Pakratt" TNC, and Kenwood 2-meter FM transceiver.

Figure 1-2. The author's "auxiliary" packet radio setup using the home's main computer along with an AEA PK-80 TNC and Icom-275 2-meter transceiver.

any time by using a handheld FM transceiver and briefcase-size computer terminal. Imagine the application of such systems during times of emergency—we would have a telephone-type network that could move information faster than 800 words a minute! For an example of fast newsgathering, see Figure 1-3. The typhoon information shown here preceded public news reports by many hours.

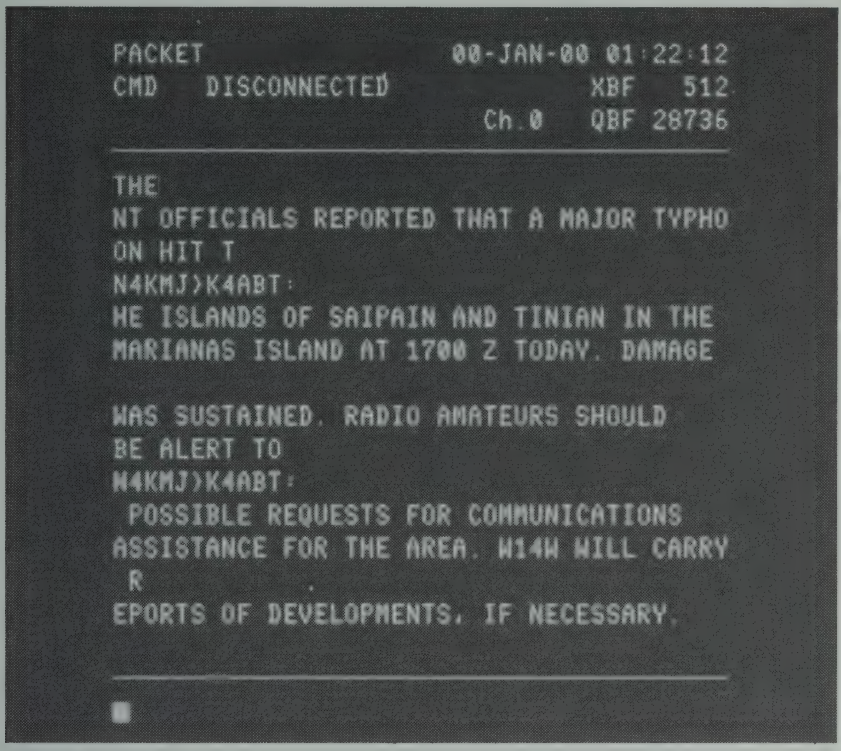

Figure 1-3. The flow of information and news bulletins are a part of packet radio activities.

While writing this book, we asked several active "packeteers" their personal opinion of packet radio's attractions. Some amateurs praised packet radio for its "perfect copy" concept and its ability to handle several conversations, or QSOs, simultaneously on a single frequency. Some hailed packet radio as a full break-in equivalent or expansion of RTTY. Others were completely sold on packet radio's ability to interlink hundreds of miles using

digital repeaters (digipeaters), its variety of usable bulletin board systems (BBS), its electronic mailboxing capabilities, and the sheer fun of operating amateur radio's newest mode. Those are only a few of packet radio's most commonly known and popular assets, not the whole story. That's why this book includes more than two chapters. Settle back, relax, and read on. We'll unfold the full packet picture and you'll be up and running on packet radio in the near future.

Packet Preview

One aspect of packet radio that appeals to newcomers is the ease with which a station can be assembled, or integrated with one's existing amateur radio setup. Adding packet capabilities to a 2-meter FM or 20-meter single-sideband (SSB) system can usually be accomplished in less than an hour. As shown in Figure 1-4, an "intelligent" interfacing/controlling unit known as a *terminal node controller* (TNC) is connected to the associated transceiver's speaker and microphone jacks, and an interface cable connects the TNC to a home computer's modem or expansion port (depending on how the computer and TNC interfacing is designed). A basic or "dumb" terminal program is then loaded into the computer, and the setup is ready for packet operation. There are a few special considerations regarding transmit and receive signal levels, transmit switching times, data speeds (both between computer and TNC and between TNC and transceiver . . . and they are not necessarily the same), plus a large number of keyboard selectable operating variables, but resolving those finer points is part of the enjoyment of packet.

One could argue that setting up a station is the easy part, and that the involved part of the venture requires learning packet's many "buzzwords" along with advanced operation techniques (e.g., determining how one's particular TNC is programmed and learning how to better control a TNC's built-in variables). But, if you enjoy computer "hacking" or keyboard tapping, you'll love packet radio.

If you're not fond of extensive menu-driven systems, however, there's another encouraging side to packet. Every commercial, kit, or homebrewed type of TNC is essentially an electrical and functional copy (or "clone" in computer language) of one standard reference: the Tucson Amateur Packet Radio TNC versions 1 and/or 2 (commonly known as TAPR, pronounced "tapper"). That single fact means that once you've learned a set of keyboard-

changeable operating parameters for packet, that information can be applied to any setup you assemble and use for packet radio. That compatibility idea is actually quite clever. Imagine: you get started right in step with every other system . . . no total relearning when changing TNCs or computers. There may be minor variations (TNC manufacturers vary slightly in the way they abbreviate some functions), but nothing is really difficult to comprehend. Relax and remember: packet was designed for enjoyable and convenient use by today's radio amateurs . . . not computer wizards or electronics engineers . . . just folks who enjoy communicating in the traditional style.

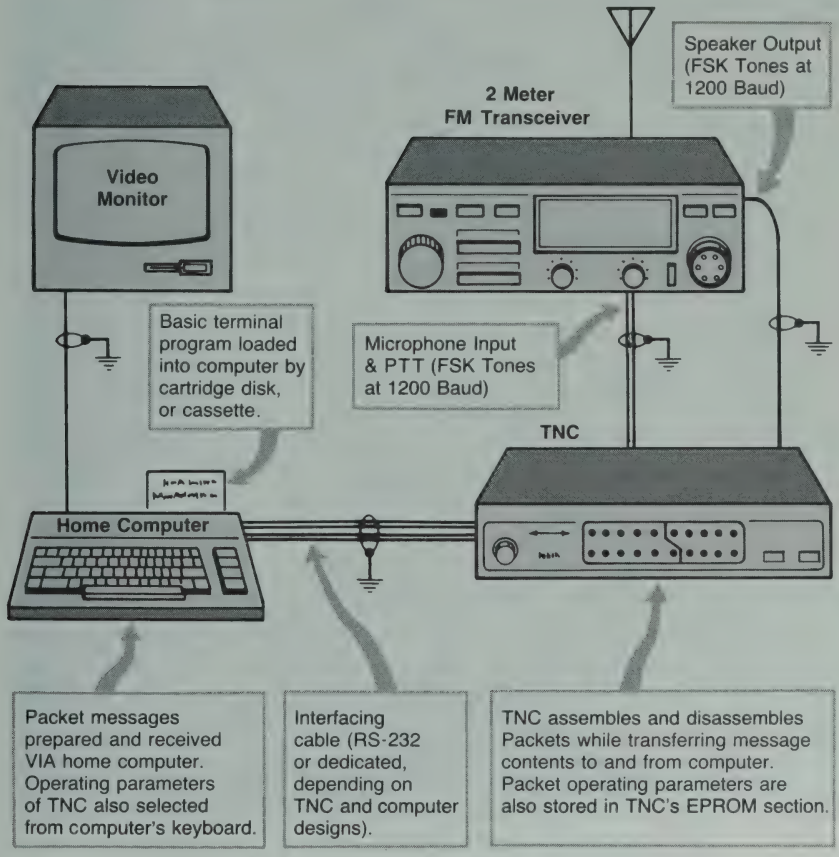
Speaker Output (FSK Tones at 1200 Baud)
2 Meter FM Transceiver
Video Monitor
Basic terminal program loaded into computer by cartridge disk, or cassette.
Microphone Input & PTT (FSK Tones at 1200 Baud)
TNC
Home Computer
Packet messages prepared and received VIA home computer. Operating parameters of TNC also selected from computer's keyboard.
Interfacing cable (RS-232 or dedicated, depending on TNC and computer designs).
TNC assembles and disassembles Packets while transferring message contents to and from computer. Packet operating parameters are also stored in TNC's EPROM section.

Figure 1-4. An example of a packet radio setup for 2-meter operation.

As this book was being written, the majority of packet radio activity was being conducted on the amateur 2-meter band. Twenty-meter packet activity was also growing in popularity, primarily as interest among users expanded and HF links became available for geographically isolated areas. The third packet band, 220 MHz, was becoming popular for high speed interstate trunks; however this frequency could change to 440 MHz after this book is printed. Several factors influence that situation: availability of VHF/UHF amateur gear, band utilizations in various geographic areas, and data rates included in packet trunks at that time. Readers are thus encouraged to join, support, and become involved in their area's packet groups to learn the latest and most up-to-date information on packet's growth in their respective locations.

The most popular VHF frequency of packet activity is 145.01 MHz, and the familiar sounding "brapp brapp" of packet communications can be heard on this frequency almost 24 hours a day. Typical off-screen views resemble Figure 1-5. You're never sure what information and conversations will fold down the screen, but they are always interesting. As packet radio growth continues, local activities are shifting to other 2-meter frequencies, and 145.01 MHz is being used for longer distance communications. There are usually several interlinking digipeaters in most metropolitan areas, however, which means many packets "addressed" to distant areas ultimately make their way back to 145.01 MHz for such network routing. Meanwhile, local packet traffic is diverted from 145.01 MHz to minimize communications delays (or improve *throughput*, as it's called in computer terms). If you're a curious investigator or packet newcomer and would like to see what we're talking about, monitor 145.01 MHz with a 2-meter FM transceiver while reading this book or tinkering in your station. After you've become familiar with packet's rapidly fluctuating tones and quite brief transmissions, try tuning in packet radio activities around the 14.103 MHz area of 20 meters. These signals are more difficult to spot and tune in because they are on the air only in brief bursts, and frequency changes should be made only during those times. If you already have a full packet system up and going, remember that *any* off-frequency tones or *any* missed bits at the beginning or end of a transmission will cause a TNC to reject the full packet as nonintelligent data. Naturally, the most logical times for checking any packet activity are during evening hours and weekends when amateurs are home relaxing.

A Closer Look at Packet Activities

As previously mentioned, numerous packet conversations, or QSOs, can be conducted simultaneously on a single frequency. This is possible through the use of time sharing. People type and read information at relatively slow speeds, but that data moves through packet frequencies or "channels" at unbelievably fast speeds. Assuming a transmitter isn't allowed to remain idle on the air when data isn't actually being sent, a vast amount of air time is available for moving other packetized messages. The system operator needs

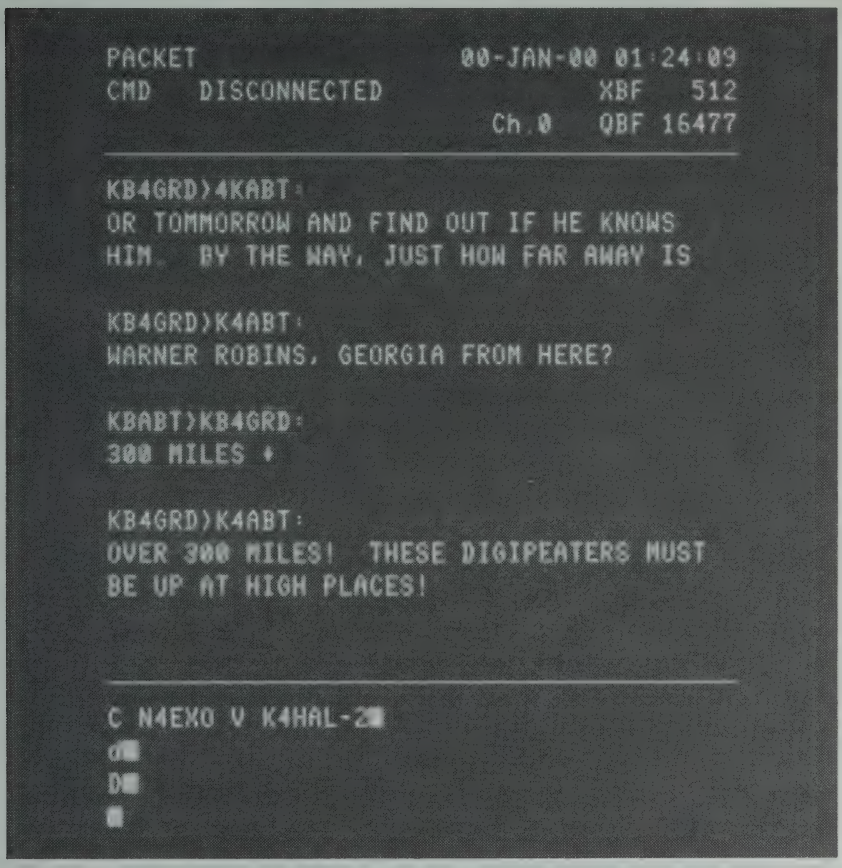

Figure 1-5. A typical off-screen view during an evening's packet activity.

to use special "to" and "from" addresses at the beginning of each packet and also check for errors at the end. Those packets are then stored in transmitting and receiving system buffers. In this way, every millisecond of air time contains highly compressed messages which operators can then prepare and read at their convenience.

Most packet QSOs are person to person in nature, because each packet of data is encoded with its own routing information, and a setup's TNC ignores any messages not addressed to its station. This doesn't preclude, however, monitoring roundtable QSOs, unaddressed CQs, or all on-frequency activity during a private QSO. Indeed, those features, and many more, are directly available via keyboard commands in any packet system. The system operator can choose to communicate privately or openly.

Packet transmissions include both local and long-distance relayed (digipeated) messages, general bulletins, invitations (such as, "I'm out for a time, but please leave a note in my mailbox") in addition to open CQs among packeteers joining in an evening's activity. Two-meter signals presently move at a 1200-baud rate, while HF packet signals presently move at a 300-baud rate. As a point of reference, 100 baud is approximately equivalent to 132 words per minute.

Calling another station via packet is accomplished by typing a "connect" command (usually abbreviated as simply "C") and related station call letters. As an example, assume K4TWJ wishes to contact (connect with) N4DKD. Since K4TWJ's call is stored in his TNC's memory, the typed command would be "C N4DKD [return]." If N4DKD is beyond K4TWJ's 2-meter simplex range and an intermediate station in the transmission path is required for digipeating, that station's call must also be included in the connect command. An example of that situation would be "C N4DKD via K4HAL-2 [return]." If N4DKD and K4TWJ were separated by 150 or 200 miles and strategically located digipeaters were between them, the command might be "C N4DKD via K4HAL-2, K4HAL-1, WB4GQX-1 [return]." The numbers following calls in that example specify specific digipeaters along the path that are requested to relay information. This concept is exemplified in Figure 1-6. K4HAL-2 was in one city, K4HAL-1 was on a mountaintop 70 miles away, and WB4GQX-1 was on a high point near the distant city. As a connect request was being transmitted from K4TWJ's 2-meter unit, the packet system's screen would display "connection in progress." The first (and maybe second) digipeater-relayed message received by K4TWJ's setup might be "echo copied." Then, after a silence, a return packet from N4DKD's system would be heard. K4TWJ's terminal would then display

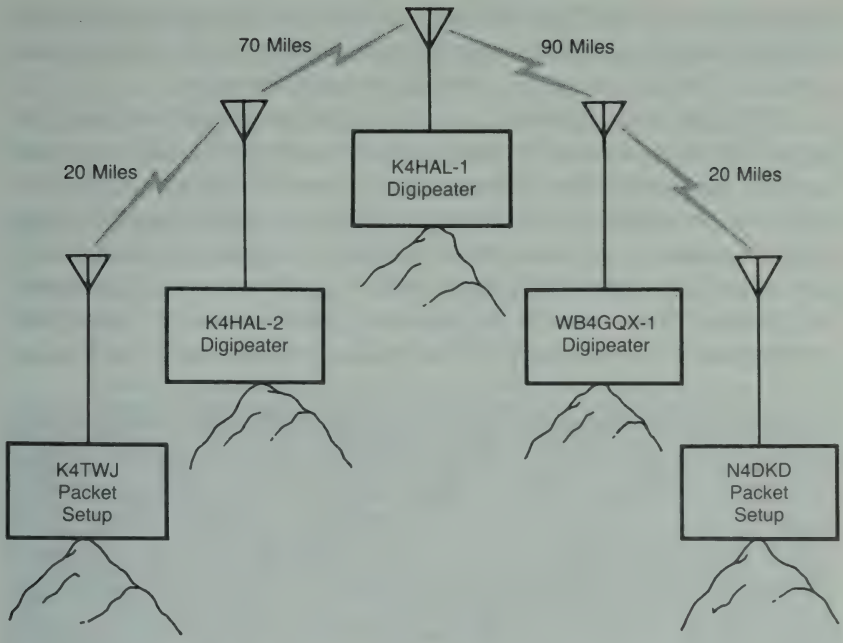

Figure 1-6. An example of the digipeating path involving three interlinked digipeaters.

"***connected," while N4DKD's screen would show "connected to K4TWJ." Both terminals would then switch from their "command" to "converse" mode. Each subsequent packet transmission between K4TWJ and N4DKD would consist of up to 256 bits of QSO text, while each setup's TNC would continue automatically adding the previously mentioned address and path data as a "header" to each transmitted packet. After the QSO was completed, either station could break the path and clear their system for additional calls by simply typing "D" (for "disconnect"). Monitor screens would then respond with "disconnected." We could have included many additional frills and features in the previous QSO overview, but we'll add those extras later as your packet knowledge expands.

Comparison of RTTY, AMTOR, and Packet Radio

Because packet radio is a printed word means of communication, there's a natural tendency to compare it with other printed modes such as RTTY

(radioteletype) or AMTOR (amateur teletype over radio). Bear in mind, however, that every communications medium available to the amateur radio enthusiast has its own special applications and advantages.

RTTY, the classic old-time form of printed communications, uses 5-bit Baudot code. Start and stop bits at the beginning and end of each word permit easy synchronization and reception by any and all viewers. A constant amplitude- and frequency-shifted audio tone or carrier is transmitted during an RTTY transmission, which means the sending station operates at a 100% duty cycle. It's as if the RTTY system is saying "I'll make a full (paragraph length) transmission, then switch to receive and read your full (paragraph length) transmission." Since RTTY has been in existence over four decades, it's the most commonly known form of printed communications.

AMTOR is a relatively recent spinoff or expansion of RTTY, but its operational concepts are quite different. AMTOR principles involve changing each 5-bit Baudot character to a 7-bit character which is always comprised of four "high levels" or binary 1s and three "low levels" or binary 0s. Transmitted in brief three-character bursts, or "chirps," the receiving station can constantly check for a proper four-to-three ratio and acknowledge or not acknowledge received data. This "break for confirmation" format provides almost error-free copy on HF bands which are quite prone to fades and interference. There are two main features of AMTOR: Automatic Repeat Request (ARR) which is a system for error checking between two communicating stations, and Forward Error Correction (FEC), in which the original transmission contains dual-repeated information that enables a receiver to correct any errors due to signal fades. The constant switching on and off or transmitting data and then listening for acknowledgment ("ACK/NAK") reduces the time a transmitter is actually "on" but requires fast transmit/receive (and recovery) times. Usual operations involve one station making a full (paragraph length) transmission while the other "ACKs back," then call signs are exchanged and roles are swapped.

Packet radio differs from both RTTY and AMTOR in the fact that each briefly transmitted burst or packet of information contains extensive control, address, and error checking data fields along with its message information. The address specifies its originating and destination stations plus relaying stations used along its route. This information is evaluated and used by TNCs and computer terminals in each packet setup monitoring off-the-air activities. The error-checking data is used by the TNC to check packets before they are displayed so a system can automatically ACK/NAK a reception. Station operators are then free to concentrate on actual exchanged information in

a break-in manner; that is, a receiving operator can interrupt a transmission whenever necessary. Message information in each packet may contain up to 256 characters. However, packet's extremely fast data rate (1200 baud on VHF, and 300 baud on HF bands, are typical rates at this time) compresses each transmission into five seconds or less. Since each packet terminal is fully alert and ready to receive data when it's not transmitting, messages seem to move both ways almost simultaneously (and among many stations on the same frequency). Figure 1-7 demonstrates that concept. Typical transmission lengths are three or four sentences rather than full paragraphs. This results in a form of printed two-way conversation. Indeed, each communicating packet party can comment on past statements during a QSO.

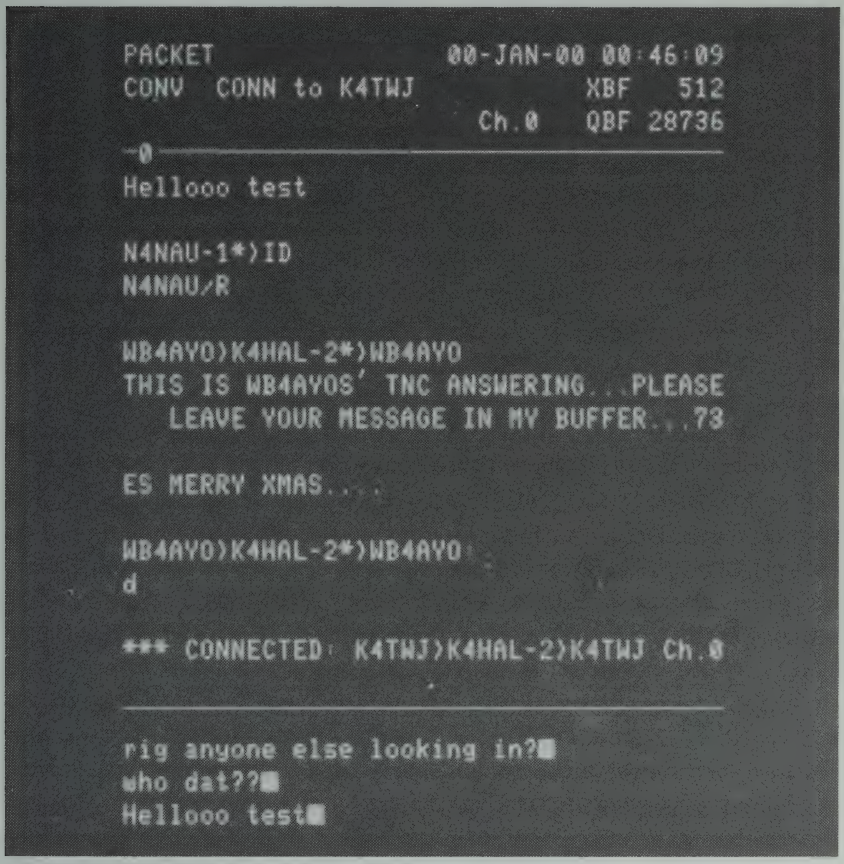

Figure 1-7. The rapid transmission speed and continuing flow of information among many on-frequency packeteers.

As you're typing a message to me, for example, my transmitted comments might be received and printed on your screen's top area. You might then tap [return], transmit three or four lines to me, and continue typing additional comments while listening and watching for my next reply.

Overall, then, we can see that the three modes of RTTY, AMTOR, and packet are quite different in formats and applications. It's also logical to assume many amateurs will find all three modes useful in their stations. If an amateur's activities are essentially confined to VHF bands or if only one printed medium is desired, however, packet radio is an extremely logical choice. Packet radio may be new, but it's definitely "hot" and growing.

Packet Links, Networks, and Electronic Mailboxing

The unique structure of packet transmissions makes them ideal for interstation relaying and "addressed message" type use. In many respects, then, each packet could be visualized as a separate piece of electronic mail passed between interlinked stations. A packet's leading, or address, information is used for routing similar to the way zip codes are used by the postal service. A radio packet can be "opened for inspection" anywhere along its route, however, without being "damaged." This situation provides a necessary means of ethical compliance and, at the same time, station-to-station linking and/or multipoint networking. Although packet's phenomenal growth surely makes its future penetration difficult to calculate (and predictions will surely be underestimated), nationwide packet networks are sure to be commonplace within the coming year. A radio amateur in a large eastern U.S. city will easily communicate with an isolated western plains amateur. Long-distance receptions, or "DXpeditions" from the Caribbean or even the South Pacific will pass health and welfare messages back home via packet. Portable packet setups will be used extensively during emergencies, and bulletin board systems (BBS) will keep all areas posted on a situation's status.

An encouraging number of large packet networks are in daily use at this very time. It's presently possible to move messages up and down the eastern U.S. seaboard during several hours each day, for example, and similar networks are growing in the middle and western parts of the country. So how might a local link evolve into a national network? That question almost answers itself. An amateur residing near the fringe of a local area network

(LAN) initially decides to join in that activity, and in so doing, he or she enters a totally new world of communications using amateur radio. At the same time, the new packeteer can become a vital digipeating link in the formation of another network. One at a time, additional fringe area packeteers join the action and push the LAN's tentacles toward a major network's center. After that vital path has been pioneered and its rewards have been enjoyed, the importance of replacing individual or borrowed packet setups with dedicated mountaintop digipeaters is quite obvious. A few packeteers combine funds, link to a large network, and similarly create an additional branch from that large network. A few more links or branches evolve, and large networks soon merge into even larger networks. Somewhere along the way, a packeteer sets up an open-access bulletin board system to store messages for both general and specific station use. Other packeteers leave and retrieve notes on the bulletin board depending on their operating trends, times, and preferences. Also along the network, other packeteers establish HF and/or OSCAR satellite links, or gateways. Properly addressed packets move off the network at these points, possibly undergoing significant speed changes, travel to their destinations, and their replies ultimately return (via that gateway) back to the network. Such are the intertwined and ever expanding ways of packet radio.

Equipment Considerations

Assuming your interest and enthusiasm have now been aroused sufficiently, subsequent questions will concern exactly what equipment is required to join the packet revolution. Stated in general terms, those items consist of: an amateur VHF or HF transceiver and antenna, an inexpensive home computer (programmed as a basic or "dumb terminal"), and an "intelligent" interfacing unit—the TNC (terminal node controller). As shown in Figure 1-8, some amateurs assemble those packet setups in ingenious ways. Here the top unit doubles as a digipeater, and the bottom keyboard folds upward for carrying. Assuming you plan to join the mainstream of packet activity, there is a wide variety of commercially manufactured 2-meter FM transceivers ideally suited for packet operation. The main factors to consider in such units are transmitter activation of PLL lock time when keyed via their push-to-talk line, receiver recovery time and signal-to-noise ratio, as well as the availability of extra microphone and speaker plugs for connecting audio lines to and from the transceiver and TNC.

Figure 1-8. This interesting and ingeniously portable packet radio setup is owned by K9EGA.

Most home computers that can be programmed as a basic terminal are quite suitable for use in packet radio setups. One should consider their TNC's interfacing capabilities before selecting a specific computer, however, to ensure their RS232/TTL/expansion port compatibility. Advanced Electronic Applications, Inc. (AEA) manufactures the popular PK-64 "Pakratt" TNC, for example, and it is presently designed for exclusive use with a Commodore 64 or 128 computer (additional details on the outstanding "Pakratt" are included in our equipment survey chapter). Remember that all units (including software, when that item isn't included in the TNC or "Packet Package") must work together to create a smoothly functioning system.

Assuming HF operations are also a part of one's packet plans, several options in related transceivers are worth considering. That unit should naturally be capable of reasonably fast transmitter activation after its push-to-talk line is energized. This isn't a serious problem with modern transceivers, however, since they seldom include massive mechanical relays in their transmit-receive (TR) sections. Additionally, nearly all TNCs include a "TX delay" feature that can be changed at the keyboard to permit operation

with slower TR switching transceivers. High-power linear amplifiers with large and "long arm travel" relays, however, may present a different situation. Check your unit and its TR relays to ensure sufficient transmit switching times. Receiver features worthy of consideration include: selectable bandwidths in the single-sideband (SSB) mode, passband tuning or intermediate frequency (IF) shift, receiver incremental tuning, and good long-term stability. Because packet transmissions are "bursty" in nature, a wide bandwidth is useful for signal spotting, and a narrow bandwidth is ideal for signal copying under adverse conditions. Passband tuning and receiver incremental tuning help make the most of a receiver's response without adversely affecting transmitted signals. Long-term stability is especially important, because each packet's leading and ending data bits must be received properly, and conventional visual methods of fine-tuning frequencies are not adequate. On the positive side, however, the short durations of packet transmissions usually make few demands on a transmitter's final RF amplifier section. As a result, most transceivers operate at a cool and comfortable temperature during packet operations.

Joining the Packet Action

If you're a curious investigator or packet newcomer, we heartily suggest you get to know and visit one or more packeteers in your area. This first step can provide a vitally important personal exposure to packet, and you can learn any special operating techniques or frequency arrangements used in your city or state. In addition to acquiring "hands-on" insight to the various packet systems, there's a good chance you'll learn about some special equipment deal or group project that will reduce your expenditures. Often, the most attractive equipment deals or bargains surface *after* one has become involved in the pursuit. Joining activities with existing packeteers could uncover such opportunities precisely when they're needed.

One of the most convenient ways to locate other packet amateurs involves both monitoring and casually voicing your interest on a local 2-meter FM repeater. Most packeteers typically own two or more VHF FM transceivers, so there's an extremely good chance you'll connect with them and be ushered into the packet pool in record time. Subscribing to packet newsletters or magazines and reading packet columns in monthly amateur radio magazines is another beneficial means of spotting active packeteers.

Assuming you visited my personal packet setup for an evening's exposure, you would surely acquire some valuable packet experience. The informal tour would begin with our simple vertical antenna installed beside

the packet setup's room. An elaborate antenna isn't desirable in my situation, as I would create distant packet and digipeater interference, which may remind you more of cellular phone than 2-meter FM systems. Inside, the packet setup itself sits on a separate desk rather than being combined with the HF station. This arrangement allows both setups to be used independently or simultaneously without distractions. In-progress packet QSOs are rolling down the monitor's screen. Call signs are automatically being placed at their transmission's beginning. Our packet system's menu and options are reviewed, then your own call is substituted in the system's "MY CALL" prompt. You're ready for a packet QSO, and someone's calling CQ. You type that person's call, the relaying digipeater's call, and push [return]. The 2-meter transceiver activates automatically. Upon returning to receive, you hear your previous packet signal being relayed (digipeated). The outgoing call echoes on our packet screen. Silence. Did he receive our call? I explain the time involved in digipeating. A couple of other packets are heard on the 2-meter unit. Nothing. Suddenly, our monitor emits an enthusiastic "wheoo, wheoo, wheoo," and the screen proudly displays "connected (to XXX-)." Our call has been answered! Since our TNC automatically switched from command to converse mode, we jump right into the printed communications game. "How long have you been involved with packet? . . . how did you get started? . . . what interesting things are happening in your life?"—the topics never end. An hour passes rapidly. My gosh, we haven't even begun our serious study of operational techniques. A friendly goodbye and 73, followed by "D" and [return], and your first packet QSO comes to a pleasant close.

This "hands-on" overview of packet may have been brief, but we hope its impressions are longlasting. Subsequent questions seem to change from "What can I do with packet?" to "When can I join packet action?" Fortunately, the answer to the second question is "right now!" Packet is indeed an active pursuit. Allow yourself a couple more days at this point, however, and read a few more of this book's chapters. Our detailed views regarding equipment and operating, for example, include a number of significant points that may influence your setup's plans and layouts. Naturally, we want you to become the best possible packeteer. Welcome to the world of packet radio!

Summary

As this chapter has illustrated, packet radio is indeed a world of pleasant enjoyment and useful applications. A system can be used in an exclusively VHF manner, or it can be combined with other amateur radio activities.

Although still in its infancy, packet's popularity is growing on a daily basis. It has already proven its worth during emergencies, such as large California fires and eastern U.S. floods, by relaying hundreds of messages faster than numerous audio links working together. These capabilities are possible because packet operations connect one computer terminal directly to many computer terminals, with amateur radio serving as "hookups" for that wireless network.

Packet radio is especially attractive to amateurs interested in computers and/or lacking technical electronic backgrounds. Station assembly is a snap—it can be installed almost anywhere—and required antennas can be placed inconspicuously in any environment. After assembly, a complete world of communications unfolds right at the operator's fingertips. There's an amazing and quite real feeling of being connected to a massive amateur radio network.

Unlike many new activities that seem difficult to understand and perfect during their early stages, packet's concepts are easy to comprehend right from day one. Expansions normally take the form of additional software rather than hardware. That is, you learn how to use your packet setup with more flexibility and efficiency, how to contact and connect with distant stations, how to use bulletin board systems, etc., as you go. The capabilities of the medium will constantly amaze you, and the best way to prove that point is by experiencing packet radio yourself. So settle back, read on, and start visualizing how you can become involved with the fascinating world of packet radio.

Basic Concepts of Packet Radio

It isn't necessary to have an extensive knowledge of packet radio's technical concepts to enjoy the activity. However, a clear understanding of its basic operational concepts can be helpful. Therefore, we've elected to discuss those two areas in separate chapters for your reading convenience and understanding. While there's some natural overlap between the two, this chapter will deal primarily with the basic facts or nontechnical side of packet radio. The next chapter will delve into packet's technical complexities.

Because packet radio is an exceptionally flexible mode of communications and because the majority of its variables are controlled directly by the computer keyboard, several operating parameters discussed in this chapter will be reiterated in Chapter 7 (The Ins and Outs of Packet Radio Operations). Our objective in this particular chapter is simply to introduce packet's operational concepts. We understand that each amateur may use different equipment in his or her packet setup, and each amateur's operating preferences are different. Naturally, you should be able to tailor your equipment to your own needs. Let's begin with an overview of each item's purpose in a packet setup.

Overview of the Packet System's Concepts

Since many amateurs are familiar with or have been exposed to modern RTTY setups using home computers and compact but elaborate interface units, there's a natural tendency to assume packet radio systems look and operate the same way. However, this isn't completely true. RTTY interface units convert tone shifts to voltage level changes and vice versa for mating transceiver signals and computer data. The associated computer is

programmed with language conversion tables for changing Baudot or CW (continuous wave) to ASCII (a standard code used in data transmission). In other words, the interface is a "dumb converter" and the computer handles intelligent manipulations of converted data. That arrangement is shown in Figure 2-1.

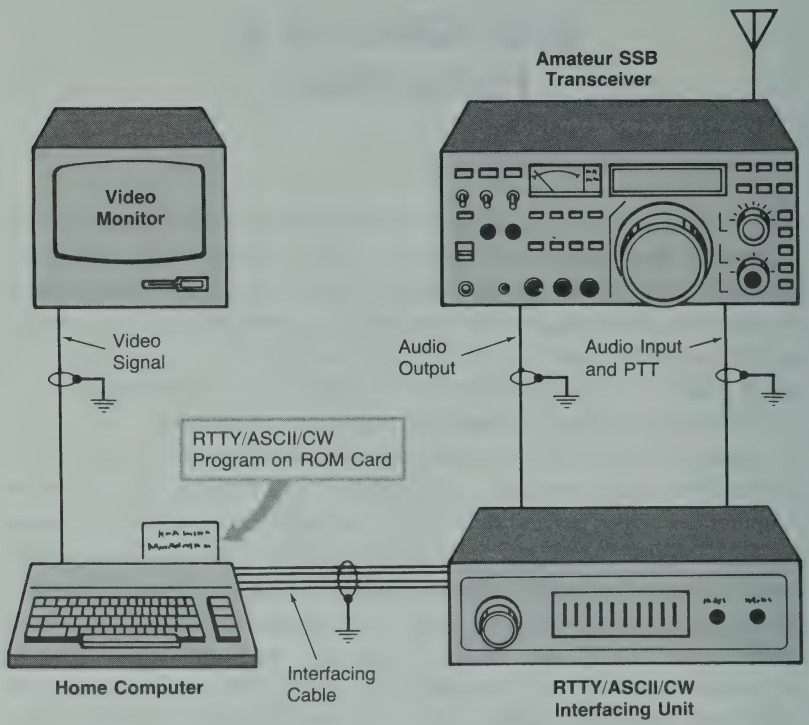

Figure 2-1. Typical interconnections of a computerized RTTY setup for amateur radio use.

The TNC used in a packet setup has two major functions: it's a tone/voltage interface and an intelligent data processing device. Except for the fact that it operates at substantially higher speeds and slightly different audio frequencies, the interfacing section of a TNC is similar to RTTY-type interfaces. The TNC's high-level data controlling section is quite sophisticated, however, and could easily be thought of as an independently operating microcomputer. Its circuitry includes a microprocessor, EPROM and RAM memory, and data buffers. This section's responsibilities include assembly

and disassembly of transmitted and received packets (adding headers, checking parity, etc.). This process is handled automatically by the TNC, along with ACK/NAK evaluation of received data and checking for similar ACK/NAK response to transmitted data. The TNC also provides "housekeeping" of all packet-related operating parameters. The TNC's software is retained in its own EPROM (or equivalent type memory), and it can be changed or reset directly from the interconnected home computer keyboard. This arrangement provides a great degree of flexibility and operator convenience. See Figure 2-2 for a diagram of the different sections in a typical setup.

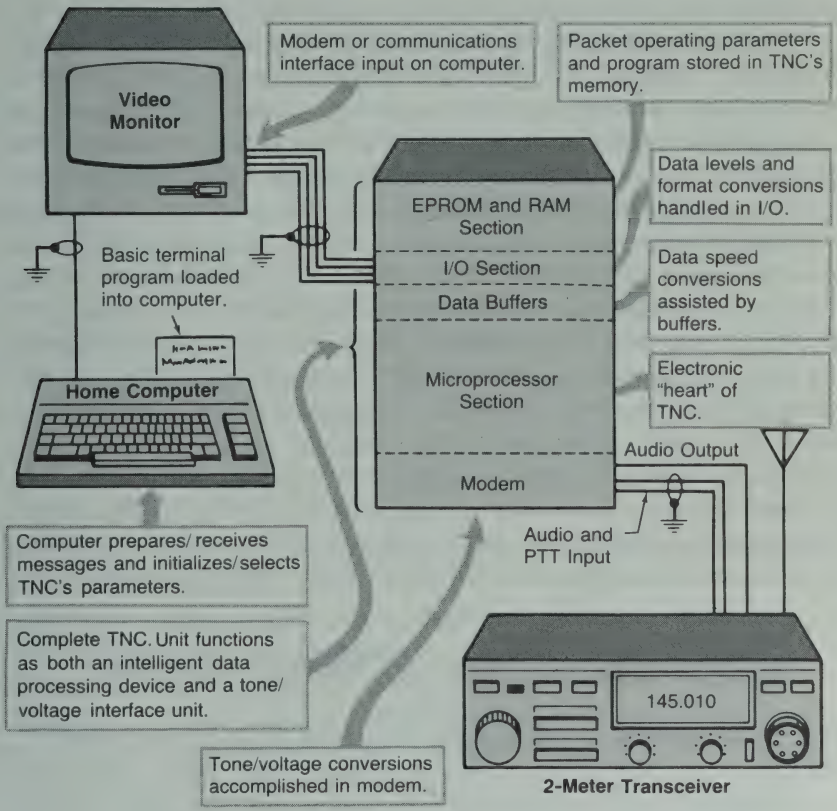
Video Monitor
Modem or communications interface input on computer.
Packet operating parameters and program stored in TNC's memory.
Data levels and format conversions handled in I/O.
EPROM and RAM Section
I/O Section
Data Buffers
Data speed conversions assisted by buffers.
Basic terminal program loaded into computer.
Microprocessor Section
Electronic "heart" of TNC.
Home Computer
Audio Output
Modem
Audio and PTT Input
Computer prepares/receives messages and initializes/selects TNC's parameters.
Complete TNC. Unit functions as both an intelligent data processing device and a tone/voltage interface unit.
145.010
Tone/voltage conversions accomplished in modem.
2-Meter Transceiver

Figure 2-2. Operational breakdown of various sections within computer, TNC, and transceiver.

There are two additional points which should further clarify the TNC's status or role in the packet radio setup. Assuming a TNC and amateur VHF FM transceiver are interconnected and a home computer is temporarily used for "initializing" or setting the TNC's parameters, the TNC and transceiver could be used for automatic activities such as digipeating that don't require an operator. Secondly, the input/output (I/O) data speeds between the TNC and transceiver and the I/O speeds between the TNC and home computer are often selectable and can be set or initialized from the computer's keyboard. A TNC is a versatile unit that permits operation with a variety of computers and packet networks, so you must set it for the specific I/O speeds you desire. The intelligent TNC then permanently stores that information in EPROM, where it can be accessed and easily changed at a later time if necessary.

The home computer's role in a packet setup also is twofold. First of all, the unit functions as a basic communications terminal with multiple transmit/receive buffers, etc., for "conversing" or preparing and reading messages from other packeteers. Secondly, the unit functions as an input terminal for "commanding" the TNC's parameters. These two modes are usually accessible on universal clone-type TNCs by typing "CMD" or "CONVERS." Computer-dedicated TNCs such as AEA's superb PK-64, however, include the capability of automatic CMD/CONVERS switching. This may sound complex, but the operation of a packet setup is actually simplified with the help of a computer. When you power up a computer and TNC, your computer's screen is in CMD mode. You select the band and speeds desired, insert your call (if it's not stored in EPROM), and join the action. If you desire uninterrupted QSOs, semirestricted QSOs, more or less transmit time delays or retries on initial connects, etc., you merely "call up" another "screen" of parameters and select with the keyboard. In other words, you can operate packet in a strictly nontechnical manner or you can get as complicated as you want. The choice is, to a large extent, up to you.

Mating Computers, TNCs, and Amateur Transceivers

The next logical area of attention has to do with the way "nondedicated" items are electrically mated to create a working packet system. Obviously any randomly chosen computer and TNC can't simply plug into each other without some forethought or preplanning. If you're not using a specific packet-dedicated setup (such as AEA's PK-64 and Commodore 64 which are specifically mated via game port connectors), your first concerns are

data voltage levels and speeds between computer and TNC. The output or modem port of some computers has TTL levels of +5 volts equalling binary 1 and 0 volts equalling binary 0. Other computers provide direct RS-232 connections or modem levels such that +12 volts equals binary 1 and −12 volts equals binary 0. A few popular home computers (such as the Commodore 64) include their own interpretation of RS-232-type voltages, and a known level modem interface must be connected to their modem ports. Your guiding light in each of those situations is the same: study your unit's instruction manuals and ensure you're properly mating according to their stated parameters. Remember those manuals are more familiar with your unit than you or your friends may be. If necessary, pull out your trusty voltmeter and confirm your unit's levels with those stated in the manual. You may also need to purchase an optional RS-232 modem adapter for mating your particular computer and TNC. Again, the prime advice here is checking the manuals for your computer and TNC. Most TNC manuals are quite elaborate, and they'll probably guide you each step of the way on interconnection compatibilities. Data speed adjustments are usually resettable and adjustable on TNCs, and shouldn't prove troublesome unless you're attempting to use a strictly off-brand or unfamiliar computer or data terminal. If you suspect trouble in this area, always check the terminal's manual (preferably before purchase).

After you have connected successfully a home computer with a TNC, a conventional "dumb terminal" program must be loaded into the computer for use in packet communications. This is the same type program the computer uses for modem and telephone communications (such as accessing CompuServe). The computer doesn't know any difference between modem connections and TNC connections: it's merely acting as a dumb terminal and feeding data to a "black box." Since that basic terminal program is essential software, however, be sure you acquire it before blindly purchasing a "bargain" computer.

Interfacing a TNC with an amateur transceiver is typically the easiest part in creating a packet setup, but there are a couple of points to consider. First, check to ensure that your TNC and transceiver are "transmit-keyed" in a similar way. Since most modern transceivers are transmit-keyed by grounding a +12 volt push-to-talk line, most (but not all) TNCs are wired accordingly. If your transceiver uses negative or high-voltage keying (−125 volts, such as that used in older vacuum tube gear), an extra keying relay and DC supply like that illustrated in Figure 2-3 may be necessary.

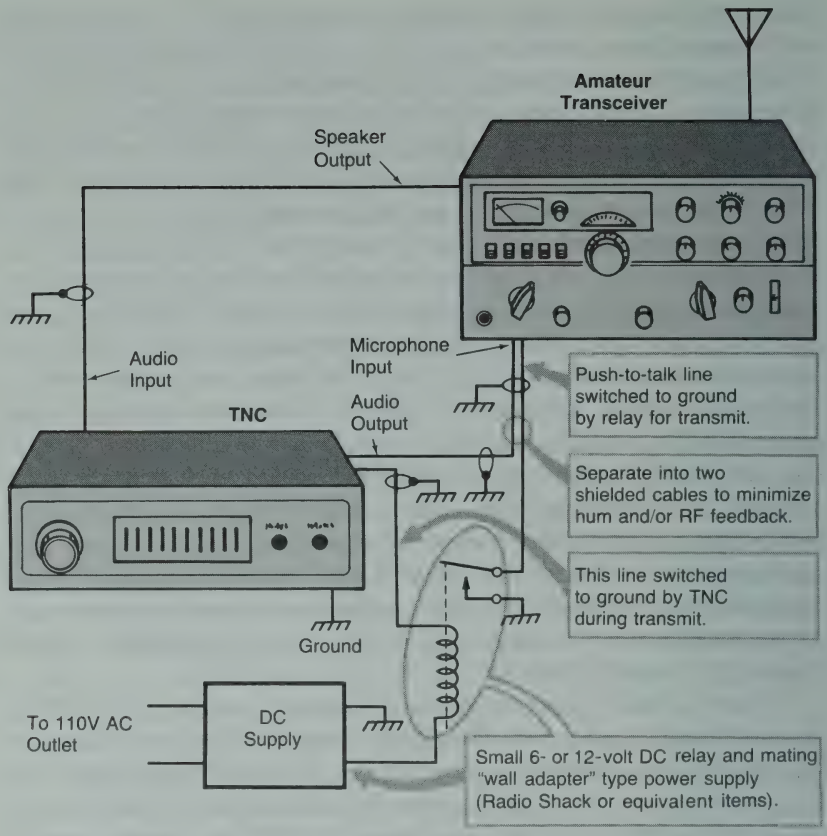

Figure 2-3. Alternate push-to-talk keying arrangement that can be used with modern TNCs and older model VHF or HF transceivers employing negative or high voltage keying.

Setting the signal level from the transceiver to the TNC merely involves opening the squelch and varying audio volume until a smooth "tuning ball" indication is produced on the monitor's screen. This tuning indicator may be built into your TNC's software, it may be included on the TNC's front panel, or it may be an "add-on" option. Setting the audio signal level from the TNC to the transceiver is a slightly more critical adjustment. If possible, monitor your transmitted packet signal on an auxiliary receiver. Select an unused frequency, then transmit a packet signal for testing. Vary your TNC's

output or transceiver's mike input control as described in your TNC's manual until the audio sounds clean and crisp on the auxiliary receiver. Next, switch back to a packet digipeating frequency and transmit your own "connect" request. Quickly switch back to receive and listen for your packet to be relayed (and printed on your screen) intact. If that relay isn't achieved, vary the TNC output very slightly and try again. Figure 2-4 should give you the idea. When you hit the proper deviation level, the digipeater will immediately relay your packet signal intact. It's that easy!

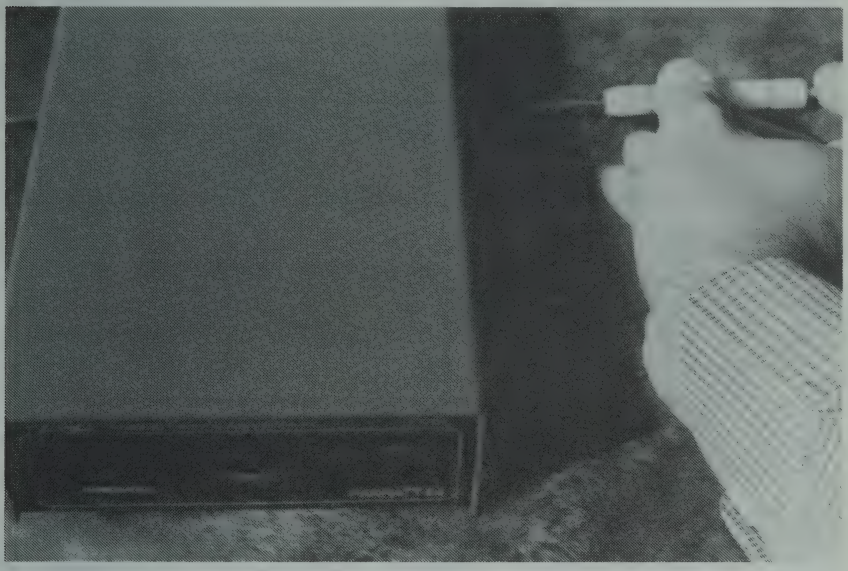

Figure 2-4. Adjusting a TNC's audio output level for proper FM deviation or modulation percentage.

Packet Terminologies and What They Mean

As you're probably beginning to realize, roughly 95% of packet radio's operating commands and internal parameters are under direct software control. Selection of these TNC-stored functions is achieved from the mated home computer's keyboard. Obviously, the key to successful and enjoyable packet radio communications is recognizing the terms for these functions as they usually appear on your monitor's screen. This set of operating commands and internal parameters is quite similar or at least recognizable on any TNC. Let's take a look at the most common terms and their functions.

There are presently two generations or versions of TNCs in general use, and they are appropriately dubbed TNC-1 or TNC-2. The units are relatively compatible and similar in functions, except TNC-2 units include an expanded set of operating parameters to allow for packet radio's growth. Considering how rapid that growth is, it's quite possible a TNC-3 (or TNC-4?) may evolve during this book's publication. Things move fast in the world of packet radio. Most importantly, however, is the fact that all TNCs include a relatively similar set of inner operating parameters with easy-to-learn terminologies. That is, they do basically the same thing but use slightly different keyboard commands to address those functions. After you've learned what to look for, recognizing a specific TNC's commands to achieve that end is a relatively simple matter—regardless of what brand TNC you choose.

There are three specific computer/TNC operating modes: command (CMD), converse (CONVERS), and transparent (TRANS). Each is selected by typing their abbreviation on the keyboard. CMD mode allows you to command the TNC's operations and select operating parameters. Two examples of TNC operating commands are CONN W6XXX V W6ZZZ [return] and D (disconnect) [return]. A variety of popular TNC "parameters" commands will be discussed shortly. CONVERS allows you to send or receive (type or read) messages in a conversation manner while the TNC handles tasks such as adding call signs or packet headers, checking for a clear frequency to transmit, monitoring for error-free copy, etc. In other words, CONVERS mode lets you exchange messages with others as if you were "wired on a private line" while the TNC performs communications-related actions. TRANS mode is basically used for transferring long files or computer-related data. This command tells the TNC to become "transparent" and ignore any strange or imbedded symbols or "control" characters it would ordinarily recognize as commands. Getting "into" and "out of" TRANS mode is typically a lengthy matter to avoid using it accidentally.

Let's now proceed to a TNC's second screen or "inner set" of operating parameters. This information is easily accessed via a simple keyboard command, and it can be changed as required. A typical view of those parameter listings is shown in Figure 2-5. A wide variety of selections is available here, so we'll highlight only the main ones for simplicity. Likewise, we remind you that slight variations in the coding or titling of parameters will be noticed among TNCs of different manufacturers.

The first and most important TNC operating parameter is MYCALL.

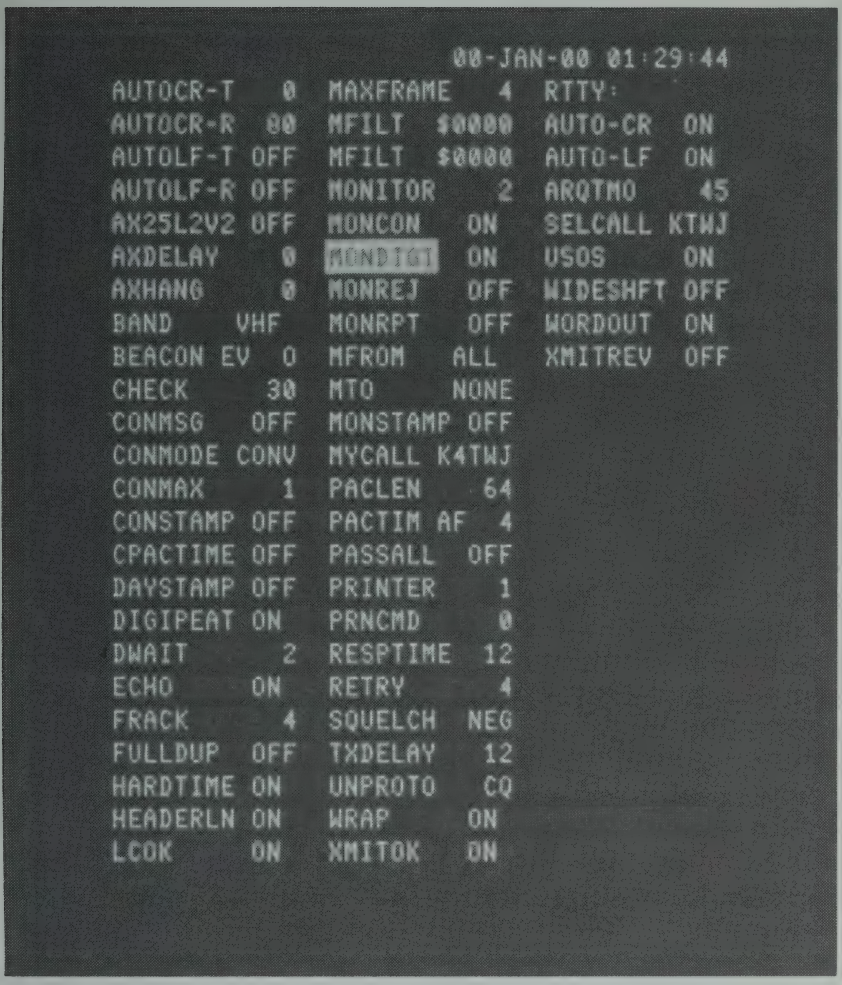

Figure 2-5. Display of the "inner set" of packet radio operating parameters.

Your own amateur call letters should obviously be inserted in this slot. The TNC will then use that data for addressing and monitoring outgoing and incoming packets. If your TNC utilizes NOVRAM storage, typing PERM will store MYCALL (and other keyboard entered parameters) permanently into memory.

Most, but not all TNCs include a BAUD rate or BAND parameter to select data speeds. 1200 baud is presently popular for VHF activity, and

300 baud is popular for HF activity. Most TNCs default upon power-up to 1200 baud, while some, such as TAPR's TNC-2, require specific baud rate commands.

TXDELAY is a very significant parameter which specifies in milliseconds how long a TNC waits after a transmitter's push-to-talk line is keyed before it starts passing packet tones to its audio input. This allows for sufficient time for TR switching and PLL stabilization in the local transmitter and the distant receiver. TXDELAYS on most TNCs are selectable between 1 and 16, with each count equalling 40 ms. Usual default values are 4, or 160 ms (4 × 40 ms). If delays beyond 16 are required, an AXDELAY is available. It's selectable between 0 and 15, and each count equals 120 ms. The AXDELAY default is usually 0.

Another TR related parameter is DWAIT. This specifies the time a TNC waits after hearing the last on-frequency data before it transmits your outgoing packet. TNCs are smart: they listen to ensure a clear frequency before transmitting. We suggest checking with your local packet group on preferred DWAIT times. DWAIT counts are usually selectable between 0 and 15, with each count equalling 40 ms, and a typical default value is 2 (80 ms). Again, you'll notice minor variations among different units.

After transmitting your packet, which requires receiving station acknowledgment, the TNC waits and monitors for a specific time before retransmitting that same packet again. That ACK waiting time is designated FRACK, and is selectable between 1 and 16. Each count equals one second, and the usual default value is 3.

If a packet's ACKnowledgment isn't received after its selected FRACK period, that same packet is transmitted again and another FRACK period is initiated. The number of packet retransmissions is selectable by the RETRY parameter. Typically, up to 10 RETRYs are available before a TNC will abort this function and declare the required path "DISConnected." Common RETRY default values are between 3 and 10, depending on TNC manufacturer.

During the prime times of packet activity, such as early evening hours, you might transmit several brief messages or packets before every one is ACKed by the receiving station (or stations, if you're using a multi-QSO feature). The TNC maintains a tally of such outstanding or "ACK waiting" messages and continues transmitting them to specified stations according to FRACK and RETRY set parameters. Understanding that fact might ease your mind when you look over and spot your transmitter activated although you do not have a message for transmission showing on your screen.

Meanwhile, the TNC's MAXFRAME parameter specifies and oversees the maximum number of outstanding messages that can be handled. Its count may be set between 1 and 7, and the usual default count is 4. When that count is exceeded, additional keyboard-prepared messages will not move into the TNC until outstanding messages are ACKed or their path DISConnected. The MAXFRAME counter then starts over and permits additional computer-to-TNC input.

The maximum amount of information in each packet transmission is selectable between 0 and 256 characters via the PACLEN parameter. This is a maximum length specification, however, and doesn't dictate that a packet must be this length before it can be transmitted. A packet of five or ten words can be passed to its desired station, for example, merely by typing the message and pressing [return]. We suggest that packets as long as 256 characters be used only during times of minimum network activity (such as late nights or middays). Sixty-four character-length (or shorter) packets are preferable during busy evening hours. The usual PACLEN default value is 128.

During typical packet radio operations, all on-frequency activity is passed through the TNC and displayed on the monitor while your system is in the "DISConnected" mode. After a "CONNection," however, only packets addressed to your station are displayed. This feature that ignores other stations can be changed, however, by resetting the MONCON (or sometimes MCON) parameter from OFF to ON. MONCON ON capabilities are especially attractive when you're connected to another station and want to know what additional activities are taking place on that frequency. The only disadvantage to MONCON ON (or its equivalent command) is you'll need to watch your screen closely to ensure you're reading the proper messages.

During normal packet activities, information displayed on the screen includes the calls of related stations and their conversations, but their complete digipeated path isn't shown. Such pathfinding data is quite useful if you desire connecting with that particular station or if you're mapping available digipeaters accessible from your area. Switching the MONRPT (or equivalent) parameter ON allows the entire list of digipeaters to be displayed on monitored packets. Stations that are digipeating packets are usually marked with an asterisk, while transmitting and receiving stations are unmarked. This feature is quite useful for packet newcomers or out-of-town visitors unfamiliar with an area's accessible digipeaters or digipeating

paths. If you can copy them, MONRPT will show you how you can call or attempt to CONNect with them.

As mentioned in Chapter 1, many TNCs in a packet setup include the capability of acting as digipeaters (if its DIGIpeating function is ON). If you use that feature, your packet unit's transmitter may become quite active although you are sending very few packets from your terminal. Switching the MONDIGI parameter ON will allow you to "read the mail" on relayed packets and their related station calls. If you're away from your packet system for a brief period, switching its MONSTAMP parameter ON will initiate stamping displayed information with the time of occurrence.

Some packeteers enjoy conducting several QSOs simultaneously, and that capability is included in a TNC's software. The CONMAX parameter specifies a maximum number of stations that can connect with you at one time. Usual selections are 0 to 10, with 10 being the default count. Zero is useful if you're away from your terminal but want to store brief messages in a buffer for later review. Conversely, a CONMAX count of 10 can be quite challenging for slow typists.

A CONMSG parameter is provided in most TNCs to assist with operator actions when another station connects to you. When CONMSG is ON, and you've entered a suitable, brief greeting into CTEXT, that message will be transmitted automatically to a station connecting to you. If the CONMAX parameter prevents additional connects (for example, if CONMAX is set on 1), however, other stations attempting to CONNect with you will receive a "busy" message. CONMSG is used only in the first transmission to stations connecting with you. After that, CONMSG isn't necessary.

Another special feature with packet radio is the ability to "screen" stations attempting to CONNect with your setup. This feature can be handy if you're involved with a special interest group or would like to exchange messages without interruptions from others. A BUDLIST parameter (or its equivalent) is included in most TNCs' software, and up to ten stations can be included in that list. If there aren't any station calls placed in the BUDLIST, its "screening" capability is unused. If the BUDLIST is used, however, stations not on the list will receive a "busy" message when attempting to CONNect with your setup. Several TNCs also include the capability of "reversing" their BUDLIST and specifying only those stations they do not wish CONNecting with their setup. We'll leave that parameter's use to your own discretion.

Packet radio is also enjoying widespread use in the OSCAR satellite program, and its necessary requirements are also considered in a TNC's

software. A packet setup normally operates in a half-duplex manner; that is, it receives packets during one time period and transmits packets during another time period. Switching a TNC's parameter to FULL DUPLEX, however, permits the unit to receive incoming packets and transmit outgoing packets simultaneously. This capability is used when a satellite transmits (downlinks) on one band, such as 2 meters, while it receives (uplinks) on another band such as 70 cm. Packet communications via satellite are increasing rapidly at this time, and a full discussion of this exciting area is included later in this book.

Please remember, this discussion of operational parameters was intended as an overview of TNC capabilities presented in an unbiased and general manner—personal operating suggestions appear in another chapter. Understand, also, this is not a complete list of features or guaranteed coding that is applicable to all TNCs. Indeed, each unit has slight abbreviations and other differences that can be discovered only by reading and studying that unit's instruction manual. That manual is your personal guide to getting the most out of that particular TNC. Our overview of features, however, should help you understand the "whys and hows" associated with most TNCs.

Networks and Bulletin Boards

Up to this point, we've essentially considered packet activities and operations within one's own setup. Let's now take a look at what happens after those signals reach the airwaves, or the overall packet communications concept. That inside look will clarify how each TNC becomes a node within its own area, and it will illustrate how everything works together to make up a packet network.

Since the main purpose of both packet and amateur radio is communications, other similarly equipped stations must obviously be located within our range of transmission and reception. This doesn't impose a serious problem on HF bands, but VHF band propagation is typically line-of-sight. Fortunately, packet radio's acceptance and popularity is growing quite rapidly and even the most remote areas are being touched by its expansion. If you live in a larger metropolitan area, there's a high probability that packet activity is booming. A few minutes monitoring on the "individual system node" frequency of 145.01 MHz should confirm that. Likewise, using your packet system's MONPRT capabilities should soon reveal area digipeaters and links with other metropolitan areas. Because up to eight digipeaters can be

specified for relaying one's packet, there's an extremely good chance you can communicate with other metropolitan areas several hundred miles from your location. Like any form of VHF repeater-related activities, we suggest that you join your area's group and support any signal-relaying setups you plan to use on a regular basis. Those groups can likewise provide a wealth of information regarding use and mapping of signal relays accessible from your particular location.

If you live in a more remote area of the country, your first objective is locating other packet stations and laying plans for mutually beneficial digipeating. Once again we advise that you monitor 145.01 MHz for in-range activity and use your packet system's MONPRT capabilities for evaluating signal paths and repeating points. Such investigations may reveal one or two previously unknown packeteers between you and a large metropolitan area. Because each packet system's TNC includes digipeating capabilities, a mutual agreement could put you in touch with a high population area and possibly also provide access to a multistate network. Likewise, your own packet setup might return the favor by digipeating packets from the metropolitan area or areas into previously inaccessible locations. Assuming that a couple of equally enthusiastic packeteers become active in the newly accessed direction, they might soon enjoy the capabilities of accessing two larger networks. With such internetwork links established and proven, the final step would involve installing one or two dedicated digipeaters, and creating an even greater packet network in the process. The subsequent evolutions are truly endless, but this one example illustrates how networking is accomplished, and how it succeeds and grows. Each new packet setup becomes a node in a network, and each network grows into a continuously larger network. An example of network evolution is shown in Figure 2-6.

A number of evolutions and expansions are taking place at the "network level" of packet radio. Numerous groups around the country are developing high-speed trunk systems for moving many packets between active metropolitan areas. Most of this trunking is taking place on the 220-MHz bands using 9600 baud and higher data rates. Several areas are also developing a "Level 3" system in which users connect with a local "switch" rather than a digipeater, and exchanged data is handled on a "switch to switch" manner similar to telephone system concepts. Either of these systems may "rebuild" or "respeed" one's original message, but the end result of moving printed words in a rapid and error-free manner stays essentially the same. Additional details on trunks and Level 3 switches are included in an upcoming chapter of this book.

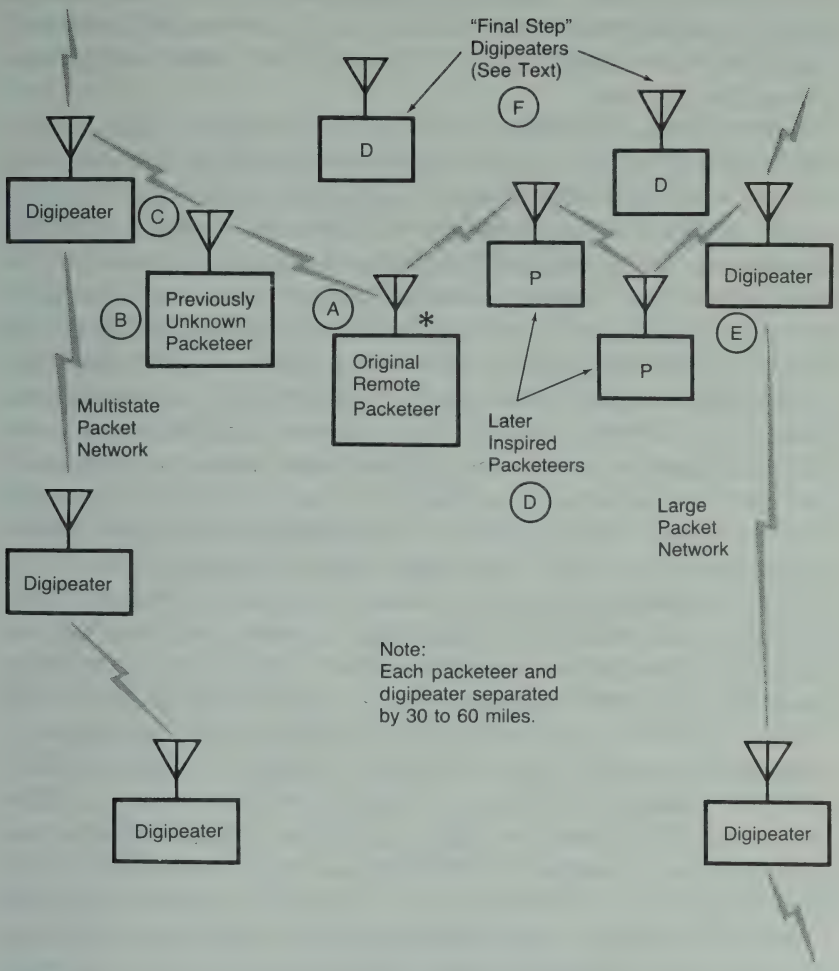

Figure 2-6. Hypothetical example of packet network evolution and growth.

Somewhere along the digipeating path of a packet network, a "gateway" setup may also evolve and expand that interlinked chain's capabilities tenfold. A gateway might be pictured as a point for "getting on or off," similar to an airplane or subway terminal. A gateway lets one change transport mediums enroute to a final destination. In the case of packet radio, gateways link VHF

and/or UHF networks with similar arrangements on HF bands and/or OSCAR satellites. This is packet's most exciting new area of interest, and one that will be covered more explicitly in another chapter. Meanwhile, here's a simplified preview.

If HF gateway capabilities are included in your area's packet network, someone must be providing digipeating relays to a popular frequency such as 14.103 MHz. With the proper access, your packet signals can travel halfway around the world or access special store-and-forward systems or bulletin board operations. You can communicate in real time, leave and/or retrieve messages, or even read timely bulletins to the amateur community at large. HF gateway activities are presently growing by leaps and bounds, and worldwide HF bulletin board systems such as the famed WØRLI setup are creating unlimited packet capabilities. The WØRLI bulletin board is operational on 14.103 MHz 24 hours a day. It supports both private station-to-station message drop capabilities and it serves as an elaborate message center for the whole amateur radio community. An extensive amount of computer data plus public domain software is also available on the WØRLI BBS. Needless to say, this BBS is the major attraction on 14.103 MHz.

OSCAR satellite gateways are another exciting area of packet interest, and their capabilities are truly phenomenal. Assuming another enthusiastic amateur provides the necessary 2-meter FM to 70-cm/2-meter uplinking/downlinking, packetized messages can be moved worldwide in a "flying mailbox" manner. Notice also that this medium is totally independent of ionospheric variations and is, therefore, completely dependable. Three OSCAR satellites, JO-12, UOSAT 12, and PHASE IIIC were launched in 1986 and 1987. Each supports electronic mailbox activities. You can pass messages to other amateurs worldwide by loading packets into the satellites and using their orbital delivery system. All of the previously mentioned multiuser concepts are being integrated into the world of packet radio at this time. Nineteen eighty-eight and beyond should prove to be banner years for packet, and the era of pocket-sized setups boasting globe-spanning communications capabilities is indeed upon us. Now's the best time to join this packet revolution and get in on the ground floor.

Summary

Considering the vast amount of information presented in this chapter, let's briefly review its points of particular interest. Packet radio creates the illusion

of an interconnected computer terminal network; however, each system is connected to the network via an amateur radio transceiver. Intrastation wires are replaced by antennas. If you enjoy printed word communications, you'll love packet.

If you're leaning toward the nontechnical side of packet, we suggest that you use a dedicated TNC/computer setup such as AEA's PK-64 and Commodore 64 or C 128 computer (or equivalent units that will surely evolve during this book's publication). Setups of this nature ensure proper mating of voltage levels and data speeds, and they include a built-in terminal program for the computer. You simply interconnect the units, learn their commands and join the packet action. If you opt for a universal-type TNC and an existing or favored computer, remember to check and confirm compatible data speeds and voltage levels, and load a general communications-type terminal program into your computer. Don't assume all computers employing a popular DIN 25-type plug or socket are compatible with RS-232 connections simply because they look similar. All RS-232s are not equal at the present time, and the lack of industry standards occasionally creates a problem. Always check a unit's manual for specific facts, preferably before purchase.

Many operating parameters are included in a TNC's internal software, and their use is the key to making packet activities flexible. Most TNCs power up or default to the most commonly preferred parameter values. Study the manuals, though, because recognizing and changing those values can open new doors in packet radio. Special attention is directed to a TNC's TXDELAY, RETRY, and MONCON parameters, as their variations are quite useful to packet newcomers. Frequency synthesized transceivers require longer stabilization times or TXDELAYs than crystal controlled transceivers. The RETRY feature can be very helpful to a newcomer just starting. MONCON ON lets you follow and understand all on-frequency packet activities while you're in CONNected or DISConnected status. This chapter explained in a general way what operating parameters do. We'll get into more details in Chapter 7.

Packet radio's features allow you to communicate with others in either brief sentences or complete paragraphs. Either way, incoming and outgoing messages are broken into packets of 16 to 256 characters and fitted with addresses of related stations. This "packetizing" happens in the background, and you really aren't required to understand its intricacies. You merely type messages, and let your TNC "do its thing."

Packet's main areas of excitement today center around multistate networks, gateways, BBS, and store-and-forward systems. Packet networks

are expanding like wildfire, and it's quite possible at least one network is accessible from your area at the present time. Both HF and OSCAR satellite gateway setups allow one to pass packets to "hop on or hop off" points, and on to distant amateurs. Message store-and-forward activities are being supported by both nationwide and worldwide bulletin board systems and by several amateur radio satellites that act like flying mailboxes. Overall, packet radio is a fascinating and enjoyable medium that's gaining worldwide popularity on a daily basis. Its future is absolutely unlimited, and you can join this activity right now and get in on the ground floor.

Technical Aspects of Packet Radio

One of the more attractive aspects of amateur radio today is that different people with different levels of interest and technical understanding can enjoy it. This versatility allows each individual the freedom to be either an "operator," an "innovator," or someone somewhere in between. It is important we realize that all levels of interest and participation are important to this pursuit. Any technical medium, such as amateur radio, requires innovation and development to keep it current with new technology, and to make it more accessible to the whole community. Likewise, even the most advanced and sophisticated technology is worthless if it isn't used. Fortunately, there are many enthusiastic innovators as well as operators who are interested in packet radio.

Currently, there is a high level of interest and activity in printed word communications and computer-related activities, with much of the innovation involving improvements in software. If you're interested in developing better software or expanding networks, opportunities for showing your creativity are endless. If you're interested in integrating new and different technologies, combining packet and OSCAR satellite communications is a fascinating pursuit. Either of those areas can be developed further by combining currently available gear in unique ways. Whichever route you choose, be assured there's a particular niche in packet that's ideal for your creative genius, especially in today's era of constantly expanding networks.

Although this chapter isn't considered mandatory reading, we encourage you to at least review its information to get an idea of the overall "packet picture." Knowledge of what happens between the time that messages are typed on a keyboard and a return reply is received provides extensive insights into both hardware and software relationships, as well as network interactions.

Likewise, visualizing packet radio's past is quite helpful to understanding future developments and expansions.

Packet Radio's Background

The opportunity for packet radio development and use originally surfaced in Canada during 1978 when that country authorized non-Baudot data type communications. During 1979, Doug Lockhart, VE7APU, began experimenting with a microprocessor-based system that became known as a Terminal Node Controller. Soon thereafter, VE7APU founded the Vancouver Amateur Digital Communications Group (VADCG), instigated *The Packet* newsletter, began selling TNC boards, and promoted widespread growth of a new medium soon to be known as packet radio. The original first version of packet embraced a limited set of operating commands and supported few network users; however, it proved there were tremendous capabilities in data terminal to data terminal communications. During 1984, VE7APU received The Canadian Radio Relay League's Certificate of Merit for his outstanding efforts in pioneering packet radio.

During 1980, ASCII data communication was legalized in the United States and VADCG TNCs using "first version" software (known as the V1 protocol) took to the airwaves.

The first United States digipeater went on the air in San Francisco, with Hank Magnuski, KA6M, at his helm. Like most homebrewed systems of that era, the digipeater sported a surplus Bell 202-type modem and 2-meter FM amateur gear operating at 1200-baud speed. Additional packet activity began springing into action in an isolated yet coast-to-coast manner. Impressive demonstrations of packet's unique ability to send full screens of error-free information in one or two second bursts created widespread excitement. Packet was coming of age in the United States, but it had some growing pains. The need for a revised protocol capable of supporting network concepts and future evolutions was becoming apparent for packet's continued growth. The first Amateur Radio Computer Networking Conference was thus held under agreements of AMRAD (Amateur Radio Research and Development Group) and AMSAT (Amateur Satellite Corp.). Soon thereafter, Dean Conners, KD2S, in Arizona founded the now famous Tucson Amateur Packet Radio Corporation (TAPR). The group's original objectives were to design and test new TNC concepts and protocols outlined in convention meetings.

During 1982, AMSAT and AMRAD held additional meetings to consider and resolve protocol discrepancies. The requirements were logically outlined: a universally accepted protocol capable of supporting a vast number of users must be implemented. The end result of those meetings was the introduction of the AX.25 protocol. It didn't acquire immediate widespread acceptance, however, which illustrates what an important part software plays in packet radio. It's as if the software becomes as essential as another electronic component, which is typical of modern computer-based activities. Consequently, with only about 200 United States packeteers active at that time, protocols were a mix of V1 and AX.25 versions. TAPR TNC-1 units were just being designed and tested.

Some major developments in packet radio evolved during 1983. The second Formal Amateur Radio Computer Networking Conference was held and the AX.25 protocol was specified as the standard U.S. networking protocol. The WESTNET packet network became reality and, for the first time, up to eight digipeaters could be linked for long-distance communications. Two additional networks, EASTNET and SOUTHNET, quickly followed suit, and the multiple interlink craze hit full force. Meanwhile, VADCG boards and TAPR TNC-1s began making their way into eagerly awaiting hands. GLB Electronics announced their commercially available TNCs. Packet radio was on a roll. Its user population was approaching 800 and growing like wildfire.

Final approval of the AX.25 protocol was established during 1984. This second version was designated AX.25.2.0. TAPR began shipping TNC-1s at an average of 120 a month, and AEA's TAPR clones were announced in the major amateur radio magazines. Packet's population was now between 2500 and 3000.

Nineteen eighty-five was a banner year for packet growth and the introduction of TNC-1 clones. AEA, Kantronics, GLB, and Heath announced their TAPR TNC-1 clones, while TAPR announced their new TNC-2 unit which featured the addition of several operating functions and a significantly expanded set of operational instructions, The industry quickly sold out to the walls and back orders were common. Bulletin board systems began to emerge throughout the country and HF interlinks made their debut. Significant packet activities also began appearing on OSCAR 10. High-speed, error-free communication was definitely accepted as a viable medium. Packet radio's population now exceeded 10,000.

In 1986, MFJ, Pac-Comm, HAL, Tono, and several other manufacturers joined the TNC market. Sales were tremendous, and packet's booming

population was inestimable. At least three companies introduced VHF- and HF-compatible TNCs. HF packet activity grew tremendously, especially on 14.103 MHz. WØRLI's bulletin board system attained worldwide popularity. Tom Clark, W3IWI, successfully bounced packet signals off the moon, and began planning schedules with others worldwide. Packet's popular 145.01 MHz 2-meter frequency was red hot, with action nationwide almost 24 hours a day. Metropolitan areas began to lay groundwork for 2400-, 4800-, and 9600-baud trunks using the 220- and 440-MHz bands. It was now possible to communicate from Florida to Washington, DC using VHF packet. A problem surfaced briefly when the FCC proposed to restrict retransmissions of third party traffic via packet radio, but rapid action by many packet groups and the American Radio Relay League resulted in a necessary waiver. Thus recovering from imminent extinction even before its capabilities were fully realized, packet radio again thrived as never before. Japan's FUJI-OSCAR 12 satellite was launched, and "flying mailbox" opportunities opened worldwide ranges using small low-power systems. Nineteen eighty-eight and 1989 promise to be even greater years for packet radio growth and utilization. Higher speed and more sophisticated networks are being pioneered and readied for widespread use. Additional OSCAR satellites featuring packet store-and-forward capabilities are constructed and prepared for 1987 and 1988 launches.

Inside the AX.25 Version 2 Protocol

As discussed in the historical review, the essential factor insuring widespread use of packet was the adoption of a universally accepted AX.25 Version 2 link layer protocol. This information format establishes a common set of rules used by all packet stations. It also allows each briefly transmitted packet to stand alone like a separate piece of electronic mail, complete with to and from addresses and its imbedded message. Each packet can then be handled in a strictly individual manner by TNCs and digipeaters. During actual packet operations, however, the station operator's only concern is terminal-displayed messages. System TNCs automatically handle protocol activities and message movements to and from their connected terminals. You simply prepare and read the electronic mail messages while the TNC handles addressing, routing, delivery, and error checking. An outline of the AX.25 Version 2 frame format is illustrated in Figure 3-1. Each packet begins and ends with a specifically coded start and stop flag. The first flag provides message synchronization,

and both flags provide error checking. Bit stuffing is used to ensure constant patterns. Notice each flag is roughly one ASCII character in length and appears only for an instant of a packet's overall length. The start flag is sequentially followed by address, control, information, and frame check sequence frames.

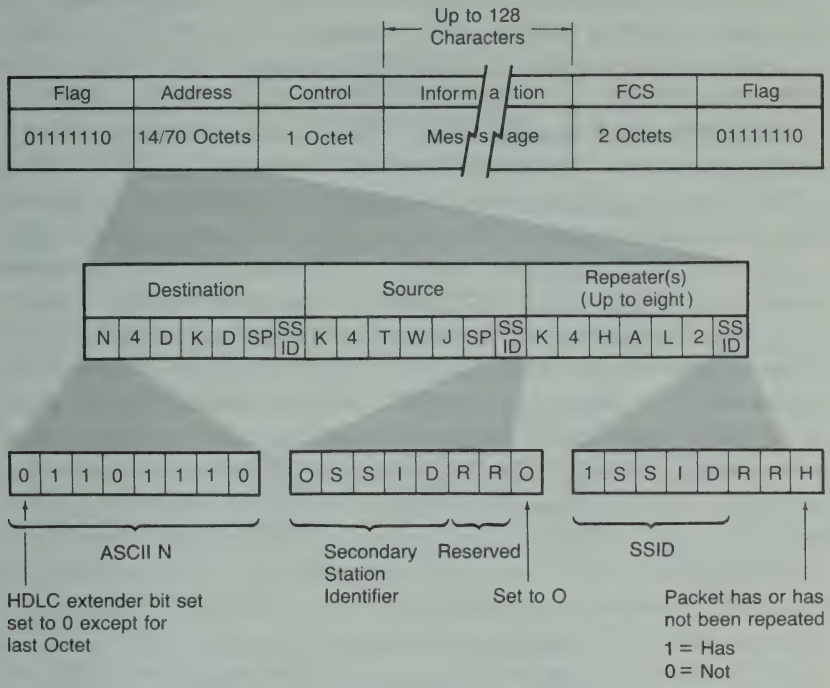

Figure 3-1. Outline of AX.25 Version 2 protocol's frame format.

The address frame consists of several subframes which are coded with call signs of the source or "originating station," the destination or "intended receiving station," and up to eight "repeater" station call signs. Each call may be up to six characters in length. Shorter call signs are padded with blank ASCII spaces. A Secondary Station Identifier is included as a seventh character to allow up to sixteen different packet stations to operate using one call sign (extended portion in lower part of Figure 3-1). Further investigation of that extended section reveals reserved bits which can be used as desired in individual networks and an "H" bit which indicates whether a frame has

or has not been repeated. This bit prevents deadlocked repetition of packets that have been repeated already.

The control frame is used to signify a connect request, ready or not ready conditions, frame numbering, and the particular mode of operation. Its information is in two parts for efficiency.

The information frame contains the packet's actual message. As discussed in previous chapters, this message can be up to 256 characters in length. A packet's overall length thus depends on the length of its information frame.

The frame check sequence (FCS) contains a data arrangement used to confirm the accuracy of the whole packet. After reception of an end flag, a TNC initiates a frame check sequence and evaluates the results. Assuming the packet passes inspection, it's passed on to the computer for display.

Packets move through an amateur radio network like letters moving through a mail system. Each TNC, whether located at one's setup or "node," or installed at a digipeater site, acts as both a modem and a special purpose microcomputer. Packets are monitored to determine if they have a destination or should be repeated by that TNC and/or if additional TNC action is required. The necessary software for handling packet assembly (when transmitting), evaluation (when reporting), and disassembly (when receiving) is stored in the TNC's Erasable Programmable Read Only Memory. Most packet radio activities thus happen mainly on the TNC and amateur radio equipment level, with home computers serving as basic terminals for inputting and outputting messages processed by TNCs. The computer also serves as an EPROM input device and parameter selector for the TNC. That capability lets one choose various options in packet operations. In addition, TNC-evaluated information can be displayed on the terminal. That feature permits looking into headers and studying various paths. Since there's quite a bit of interaction taking place between packet protocols and TNCs, our logical path for continuing this study now involves looking inside the TNC.

Internal Functions and Operations of TNCs

As we all know by this time, the TNC is that intelligent little unit installed between an amateur transceiver and a home computer, which has been programmed to function as a basic ASCII terminal. Since the basic operational concepts of most TNCs are relatively similar, their hypothetical or typical block diagram is shown in Figure 3-2. A TNC can be thought of

as having two basic parts: the modem section and the intelligent data-manipulating section. The modem is responsible for tone-to-data and data-to-tone conversions. The data-manipulating section is responsible for adding, removing, and evaluating header information and establishing various packet operating parameters. In other words, it's the TNC's brain.

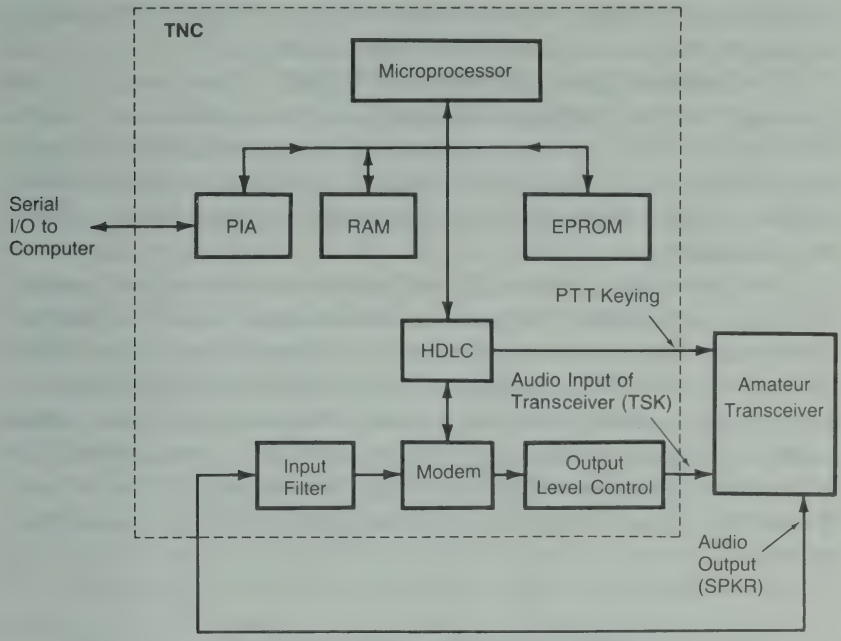

Figure 3-2. Block diagram of a typical TNC.

When powered up, packet operating parameters stored in EPROM are used to initialize the system and prepare the station for activity. Between 30 and 50 parameters are typically stored in a TNC-1's or TNC-2's EPROM memory, and they typically come up at their default settings described in Chapter 2. It's interesting to note that most TNCs also include EPROM storage areas for retaining call signs and brief connect and beacon messages when their operating power is removed.

Data flow between the TNC and computer is provided by a peripheral interface adapter chip, or PIA. This device provides level conversions such as changing TTL to RS-232 (5 volts to 12 volts in simplified terms) and matches each particular internal level to its associated output connector. The PIA may also function as a serial to parallel data converter with a random

access memory (RAM) buffering data overflow when incoming or outgoing data streams are unequal or packets must be stored. Data to and from a computer is usually in serial form, with bits sequentially following one behind another on a single input/output line. Inside the TNC, however, separate lines are used for each bit of data. This data bus usually consists of eight wires. Either a special PIA or a universal asynchronous receiver transmitter (UART) performs serial/parallel conversions and notifies the TNC's microprocessor when data is placed on its information bus.

The high-level data link controller (HDLC) in turn compiles data (message) from the UART plus necessary packet parameters to create ready-to-send packets. The transmitter's push-to-talk line is then activated and serial packet data is passed to the TNC's modem. After transmission, the HDLC removes its push-to-talk activation to permit the transceiver's return to receive operation.

During reception, incoming packet signals are converted by the modem and passed to the HDLC. The packet's address and control fields are analyzed to determine if it should be ignored or if additional action by the TNC is required. If the TNC's preprogrammed call is specified as the destination, a frame check sequence is initiated. Assuming the packet passes its electronic inspection, an acknowledgment packet is addressed and transmitted back to the source or originating station. The packet's message is then retrieved, converted to the proper format, and forwarded by the PIA to the computer for review.

Data Interfacing Considerations

There are several important factors to keep in mind regarding TNC interconnections and interactions within a packet radio system. Audio tones are being passed between the station's transceiver and the TNC while digitized voltage pulses are moving between the TNC and its related home computer. Each of these signal levels must be retained within exact limits. Meanwhile, various types of data flow and manipulation are taking place within each unit—data of quite different types, and data that surely warrants closer investigation for best understanding. Let's begin that investigation with an area that's usually familiar to most radio amateurs.

A TNC's internal modem or modem chip is used to interface packet voltages or levels with audio tones. The modem's input connects to an amateur transceiver's speaker output while the modem's output connects to the

transceiver's microphone input. This easy-to-install arrangement is quite sufficient for directing incoming packets to the TNC's HDLC and directing outgoing packets to the transceiver. These interconnections are usually the easiest to implement, since we're working at the basic audio level. Most, if not all, amateur transceivers include a rear panel socket for connecting an external speaker. The unit's internal speaker is disconnected when a plug is inserted into the external speaker jack, however, a partially inserted plug can parallel or tap that line for input to the TNC without disconnecting the internal speaker. After that line tapping our only serious consideration is adjusting the receive volume to obtain smooth packet radio copy. Usually, normal listening levels are ideal. Too much volume will cause the TNC's modem to respond to noise or distort incoming tones. Not enough volume will not provide complete packet copy. Remember that every bit within a packet must be received to be HDLC processed and accepted for display. Missing any part of a start or stop flag or any portion of a packet's text will automatically disqualify the full packet. An on-screen tuning indicator and/or TNC "tuning eye" is usually provided for confirming proper receive levels on VHF/FSK packets. The HF packet, which is transmitted via SSB systems rather than FM systems, is more critical to tune "on frequency." An accurate external frequency tuning aid is definitely suggested for such HF activities.

To clarify further, VHF packet utilizes 1000-Hz shifted tones while HF packet uses 200- or 600-Hz shifted tones. The VHF tone pair is Bell 202 modem-compatible: 1200 Hz and 2200 Hz. The HF tones recommended by TAPR are 1600 and 1800 Hz. Naturally, sharply tuned circuits and accurate tuning aids are necessary for these closely spaced tones.

Setting the audio output level of a TNC's modem is usually a quite simple matter requiring only a couple minutes. A front panel or easily accessible control on the TNC is usually provided for VHF/UHF packeting, and that feature sidesteps going inside one's compact FM transceiver. HF transceivers usually include front panel microphone or audio input gain controls, but the TNC's audio output control is the most convenient means of matching microphone/auxiliary input volume levels. Once again, only enough level should be used to produce smooth packet copy without distorting. The easiest way to check involves first setting up the packet station to transmit a simple self-test packet and monitor the transmitted signal on a separate receiver. This technique will allow you to directly monitor and check quality. After the system's audio is set to an approximately correct level, a local digipeater can be used for final tweaking (during quiet night hours, please). After a self-test packet has been transmitted and the transceiver switches back to

receive, immediately listen to hear your relayed packet. If properly accepted and digipeated, the self-test packet should then display on your own terminal, and you can experience in real time the rapid operating time of your TNC. If the packet was not digipeated, readjust the modem's output level very slightly, and try the self test again. Within one or two minutes you'll hit the precisely desired modulation level and you'll hear your packet digipeated. Your TNC will then decode that digipeated copy and pass its information to the computer for display. The previous technique is also quite useful for localizing problems in a packet station, as it rapidly illustrates whether one's transmitter, receiver, TNC or computer is performing properly. Remember, however, self tests usurp digipeater time and should only be conducted during QSO slack periods or "quiet hours." Now let's turn our attention toward interfacing considerations between TNCs and computers.

A brief study of digital electronics and microcomputers reveals their internal operations are performed using voltage levels designated as binary 1 or 0. A timing oscillator or internal clock specifies time periods of those pulses and moves the related data during operations. The data can move in serial or parallel form, depending on input/output port configurations and internal architecture of the unit. Usually, parallel data movement is used "inside" a microcomputer to permit high-speed operation while serial data movement is used for convenient "external" interfacings. In comparison, serial data might be visualized as flowing one behind the other in a fashion similar to Morse Code. That is, we don't know what the next character will be until it's received. Only one wire (plus ground, naturally) is required for movement of serial data. Conversely, parallel data requires separate wires for each of its data bit lines. If a line is "high," it's considered binary 1; if a line is "low," it's considered binary 0 (assuming positive logic). Using serial data flow, each clock pulse moves data one step along its line. Assuming universal syncing, separate devices merely listen to clock pulses and read their data with each pulse. Parallel data, however, moves "all at once" during a single clock pulse. The difference between serial and parallel data is also significant because modern computers and microprocessors function using a seven-bit language known as ASCII, which stands for The American Standard Code for Information Interchange.

A detailed listing of the ASCII character set is shown in Table 3-1. Notice the 128 character set includes both lower case and upper case characters plus a variety of special purpose/control characters. Notice, also, that numbers 0 through 9 will appear in their BCD form when bits 7, 6, and 5 are masked out.

Table 3-1.
The ASCII Character Set

	7	0	0	0	0	1	1	1	1
	6	0	0	1	1	0	0	1	1
4321	5	0	1	0	1	0	1	0	1
0000		NUL	DLE	SPC	0	@	P	\	p
0001		SOH	DC1	!	1	A	Q	a	q
0010		STX	DC2	"	2	B	R	b	r
0011		ETX	DC3	#	3	C	S	c	s
0100		EOT	DC4	$	4	D	T	d	t
0101		ENQ	NAK	%	5	E	U	e	u
0110		ACK	SYN	&	6	F	V	f	v
0111		BEL	ETB	'	7	G	W	g	w
1000		BS	CAN	(	8	H	X	h	x
1001		HT	EM	)	9	I	Y	i	y
1010		LF	SUB	*	:	J	Z	j	z
1011		VT	ESC	+	;	K	[	k	{
1100		FF	FS	,	<	L	\	l	|
1101		CR	GS	−	=	M	]	m	}
1110		SO	RS	.	>	N	^	n	~
1111		SI	US	/	?	O	−	o	DEL

Control Codes

ENQ	= acknowledge	FF	= form feed (home)
BEL	= signal bell	FS	= file separator
BS	= backspace (←)	GS	= group separator
CAN	= cancel	HT	= horizontal tab (→)
CR	= carriage return	LF	= line feed (↓)
DC1	= device control 1	NAK	= not acknowledge
DC2	= device control 2	NUL	= null
DC3	= device control 3	RS	= record separator
DC4	= device control 4	SI	= shift in
DEL	= (delete)	SO	= shift out
DLE	= data link escape	SOH	= start of heading
ENQ	= enquiry (WRU)	SPC	= space
EM	= end of medium	STX	= start of text
EOT	= end of trans.	SUB	= substitute
ESC	= escape	SYN	= synchronous idle
ETB	= end of block	US	= unit separator
ETX	= end of text	VT	= vertical tab (↑)

When a key is pressed on a home computer's keyboard, an ASCII character is created and presented at the keyboard's output. The computer then reads in the information and processes its data according to software

instructions. In the case of basic terminal operations, the binary-coded string of ASCII characters is held and manipulated and eventually delivered to the output port. The language at that point is ASCII, and the voltage levels are usually TTL or RS-232 compatible. Notice, however, those two levels *are not* directly compatible. A computer or TNC can be damaged if the two different levels are connected—always check before connecting. Basically, TTL specifies +5 volts as binary 1 and 0 volts as binary 0 while RS-232 specifies −12 volts as binary 1 and +12 volts as binary zero. Many RS-232 interfaces are quite versatile, however, and can work with variations from ± 12 volts and, because of its zero crossing between binary 1 and 0, it's quite immune to noise.

One of the main reasons for confusion in RS-232 related interfacings at this time involves an industry standard connector known as DIN-25 (Figure 3-3). Note that RS-232 is a voltage level, not a connector. DIN-25 connectors *often* signify RS-232 levels, but it isn't a universal fact. Since many amateurs will surely be using and handwiring DIN-25 type connectors several times within their packet radio life, let's briefly review their pinouts as illustrated in Figure 3-4 and Table 3-2.

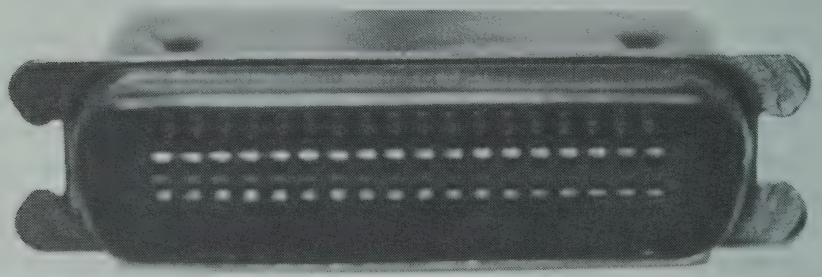

Figure 3-3. A DIN-25 plug found in many computers, printers, and modems.

Pin 1 is a protective ground which should always be used to ensure a common ground, avoid unnecessary voltage spikes and protect against shocks.

Pin 2 and Pin 3 handle the actual transmitted and received data which is used for data communications. These pins connect between a home computer and our TNC.

Pin 4 is the request to send line (RTS). When a computer has data to send, the RTS line is shifted low. The computer then waits until a clear to send (CTS) response appears on Pin 5 from the connected peripheral.

When that acknowledgment is received, data is transmitted to the peripheral in serial form via Pin 2.

Pin 6 is the data set ready line (DSR). This carries the ready to receive data response from the peripheral to the computer. In our discussion, that peripheral is the packet system's TNC.

Pin 7 is the signal ground. This connection is used for all signal-related wirings.

Pin 8 is the data carrier detected line. This connection is used when the two interconnected units are spaced some distance apart and use a telephone line with modem setup.

Pins 9 through 19 are mainly used in multisystem interconnects or modems when unattended terminal communications are employed. One example of such use is nighttime polling of various business terminals by "master computer" setups.

Pin 20 is the data terminal ready line. The computer activates this connection when it is ready to send or receive data.

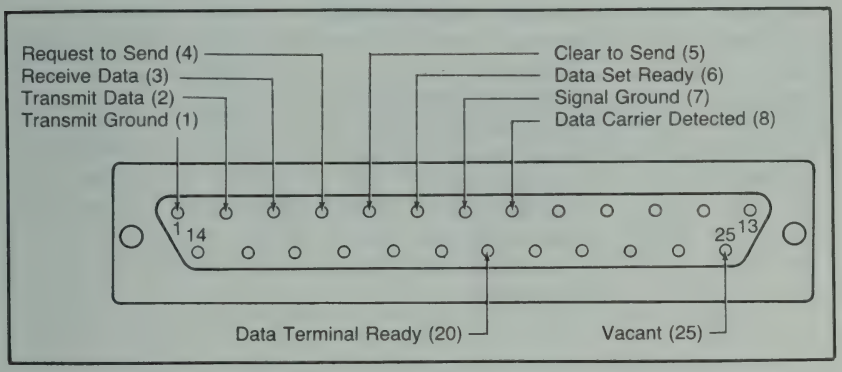

Figure 3-4. Pinout of DIN-25 connector wired for RS-232C use (viewed from its front).

This should provide a working overview of data interfacing considerations that can prove useful to experimentally minded packeteers. Armed with this knowledge, it should be easier to understand the requirements and needs which must be satisfied to interconnect different computers or TNCs. We always suggest studying those particular units' instruction manuals for maximum equipment insight, however, as few people understand those particular units better than their own manufacturer.

Table 3-2.
Description of Signals on DIN-25 Connector

Pin No.	CIA Ckt.	CCITT Ckt.	Signal Description	Common Abbrev.
1	AA	101	Protective (Chassis) Ground	GND
2	BA	103	Transmitted Data	TD
3	BB	104	Received Data	RD
4	CA	105	Request to Send	RTS
5	CB	106	Clear to Send	CTS
6	CC	107	Data Set Ready	DSR
7	AB	102	Signal Ground/Common Return	SG
8	CF	109	Received Line Signal Detector	DCD
9			Reserved	
10			Reserved	
11			Unassigned	
12	SCF	122	Secondary Received Line Signal Detector	
13	SCB	121	Secondary Clear to Send	
14	SBA	118	Secondary Transmitted Data	
15	DB	114	Transmitter Signal Element Timing (DCE)	
16	SBB	119	Secondary Received Data	
17	DD	115	Receiver Signal Element Timing	
18			Unassigned	
19	SCA	120	Secondary Request to Send	
20	CD	108/2	Data Terminal Ready	DTR
21	CG	110	Signal Quality Detector	SQ
22	CE	125	Ring Indicator	RI
23	CH	111	Data Signal Rate Selector (DTE)	
23	CI	112	Data Signal Rate Selector (DCE)	
24	DA	113	Transmitter Signal Element Timing (DTE)	
25			Unassigned	

Summary

When we step back a few paces and look at packet radio's overall picture, we can see many different levels of technical involvement that can fit any amateur's interest or desires. Both operators and innovators are welcome in packet circles and each group benefits the other. The continued growth of any medium requires the combination of use and development.

In order for all packet users to speak the same language, a standard format or protocol was adopted. Within the United States and several other areas, the present protocol is AX.25 Version 2. Considering packet's rapid growth and continuing evolutions, however, it's logical to assume that an

additional yet relatively compatible AX.25 Version 3 or Version 4 protocol will be developed in the near future. The original Canadian V1 protocol also continues to live and evolve. V2 and a new V3 protocol have been noted, and several recent TNCs include multiple protocol software for truly intercontinental compatibility. Each of these protocols consists of ASCII data formatted into compact packets containing address, control, and message information which is transmitted at rapid speeds. During packet radio operations, each station's TNC monitors off-the-air packets to determine what actions they should perform. These monitoring and evaluating actions are handled by the TNC while the home computer basically functions as a dumb (communications-type) terminal.

The internal operations become more complex when we realize that TNCs and home computers process their data in parallel form while data flow between them is in serial form. Likewise, one unit may utilize TTL levels while the other unit uses RS-232. The simple answer here involves the use of proper peripheral interface adapter (PIA) chips and level converters. Sometimes those converters are included in a TNC, and other times they must be assembled at home. The logical answer always is to check manufacturers' manuals of considered units. Naturally, there's an underlying and additional benefit to that suggestion. Not only is it the fastest and most direct path to a sought answer, it also expands your own technical knowledge and encourages you to be more independent. Most radio amateurs are more technically inclined than they give themselves credit for, and an occasional exposure to technical material can be very valuable.

Home Computers and Data Communications Terminals

The recent growth and extensive use of home computers has had an undeniable influence on our lifestyles. Indeed, personal computers and microprocessors have become two of the world's most popular and versatile items for performing both trivial and complex tasks in the most efficient manner possible. Some obvious examples would include the integration of computerized machines in industry, microprocessor-based toys for children and the wide variety of computer systems proving their merits in amateur radio setups worldwide. Modern HF and VHF transceivers with their exciting array of operating capabilities and features are good examples of this computer revolution. Today's transceivers include their own internal microprocessor or small computer which digitally controls band and filter selections, mode activations, local oscillator and band tunings, and much more. Those microprocessors are also easily interfaced to the outside world to provide complete control of a transceiver from a home computer system. Such interfacings are tremendously beneficial, especially when one is involved with crossband OSCAR satellite activities.

Basic data communications terminals or home computers programmed to function as basic terminals are also exceptionally popular and useful items in today's era of advanced technology. For example, both radio amateurs and computer fans probably have been exposed to services such as CompuServe that are accessible with a telephone and modem. There are many interesting computer services available for a nominal monthly fee. These include special programs and nationwide bulletin boards to financial planning and banking services, and even shopping via telephone. The user merely programs a computer for basic communications terminal operation, connects a modem, and telephones the service. In many respects, those computer-to-computer activities might be compared with a simplified form of packet radio.

There are message centers, transferable files, and even an on line network where one can chat with other system users. The critical difference, however, is that such systems are restricted by the telephone making them unreliable during emergencies, and each minute of use carries its fee.

Another well-known use of basic communications terminals is illustrated each day in both large and small companies throughout the world. A clerk enters an order or sale on a terminal which responds immediately with related data while informing a distant master computer of variations in inventory. Following the close of a day's business, the terminal might also be set up for late night polling by one or more master supplier computers. That concept of polling, incidentally, was also given due consideration during the early days of packet radio development. After many studies, the idea was dismissed because of the inefficiencies involved with usurping time and the necessary use of an overall "master computer." At any rate, the original home computer craze which began a few years ago has now evolved into a serious and quite beneficial part of our daily lives. The extensive use of data communication terminals and systems has also been educational and helpful in perfecting packet radio's concepts and fitting the new technology into a definite niche within the amateur radio service. Today, the future of both home computers and packet radio is truly unlimited.

While computers are exceptionally versatile items capable of numerous functions or operations, we must understand their capabilities are directly related to their software's sophistication. Simple or bare bones software can only accomplish a limited number of functions while advanced software is capable of performing many quite complex tasks. Plan your purchases accordingly. Computer software is available in several forms to mate with each person's needs and system capabilities. The most common forms of software are read only memory (ROM) cartridges, floppy disks, and cassette tapes. ROM cartridges are very attractive items because they do not require supporting peripherals such as disk or tape drives for loading. They are merely plugged into a computer's game or expansion port, and the system comes up ready for action upon powering up. The disadvantage of ROM cartridges is that they have somewhat limited capabilities (elaborate mediums) and comparatively high cost (payments for a few ROM cartridges can equal the cost of a disk or cassette drive). Floppy disks and cassettes can store and retrieve more extensive programs, but they must be loaded into the computer at power-up from a supporting peripheral. This information may not be new to many readers, but it does warrant consideration before one gets heavily involved in the home computer game. Unfamiliar new computers

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may look attractive and boast a low price tag, but the lack of personally useful software can quickly become heartbreaking. The most logical suggestion we can offer is to always locate your own preferred software, then purchase a computer which will definitely run that software. That usually means considering the most popular units among amateurs. Amateur radio related software is normally written by radio amateurs, and new computers take time to gain a foothold in the amateur community. If you're in doubt about which computers best satisfy those requirements, study the articles and advertising sections of recent amateur magazines such as *CQ*, *73*, *QST*, and *Ham Radio*, eavesdrop on off-the-air activities, then decide about your own computer system and software accordingly.

Physical Structure of Home Computer Systems

There are two basic styles or physical arrangements of home computer systems popular at the present time: the separate computer and peripheral arrangement and the master cabinet design such as IBM's PC and its "look alike" clones. The usual inexpensive home computer setup typically includes several external peripherals, some of which require their own power sources. Since the computer's on/off switch is on the output side of that power supply, and since each external peripheral is designed similarly, a switched and spike-protected AC strip like the one diagrammed in Figure 4-1 is suggested for convenient use. Assuming the AC strip is comfortably rated above the computer and transceiver system's rated wattage, it provides an ideal master switchbox for the whole setup. That way, one or two units will not be left on accidentally when the system is not being used. We should also emphasize that included transient or spike protection within the AC strip is an optional feature that should not, we repeat, should not be overlooked. Sensitive integrated circuits in computers, peripherals, and amateur transceivers can be permanently damaged by short term high-voltage pulses. Such pulses can result from inductive kicks of household motors (fans, mixers, drills, etc.) and/or from lightning bolt induction into distant power lines. Those brief pulses are voltage spikes which zip right through fuses or circuit breakers. The shorter a spike or transient, the higher its voltage. Master AC switchboxes for separate component-type computer systems have their benefits.

The master cabinet or professional type home computer system is presently acquiring widespread popularity at a phenomenal rate. This style

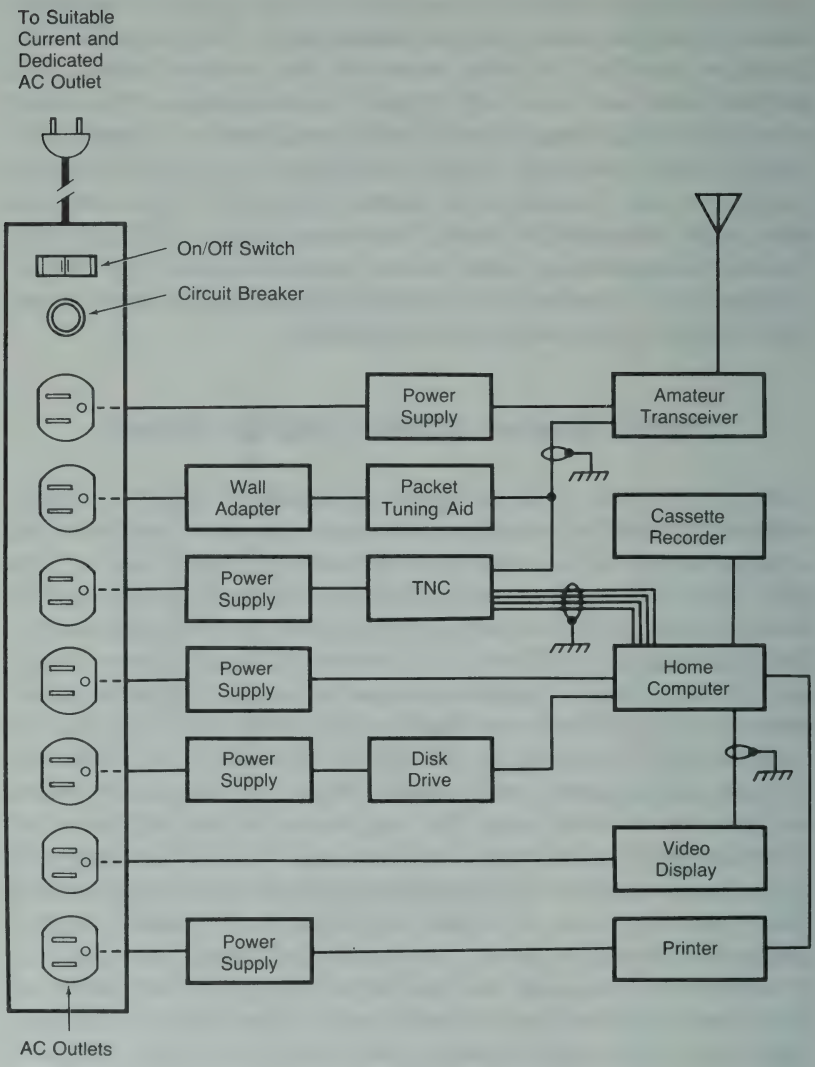


Figure 4-1. Example of AC wiring arrangement for a home computer and packet radio setup.

is destined to be the wave of the future simply because it allows for more space and is energy efficient. A master cabinet system typically includes the computer, its disk drives and power supply in one section. Plug-in PC

boards for expanded memory, modem, high resolution graphics, RF modulator, etc., can be added inside the cabinet according to one's needs. An external keyboard is used with the system. A video monitor and a printer (both requiring their own AC power) complete the system. Its outline is shown in Figure 4-2. Computers of this type include IBM, Apple II series, Apple Macintosh, and Radio Shack's best units.

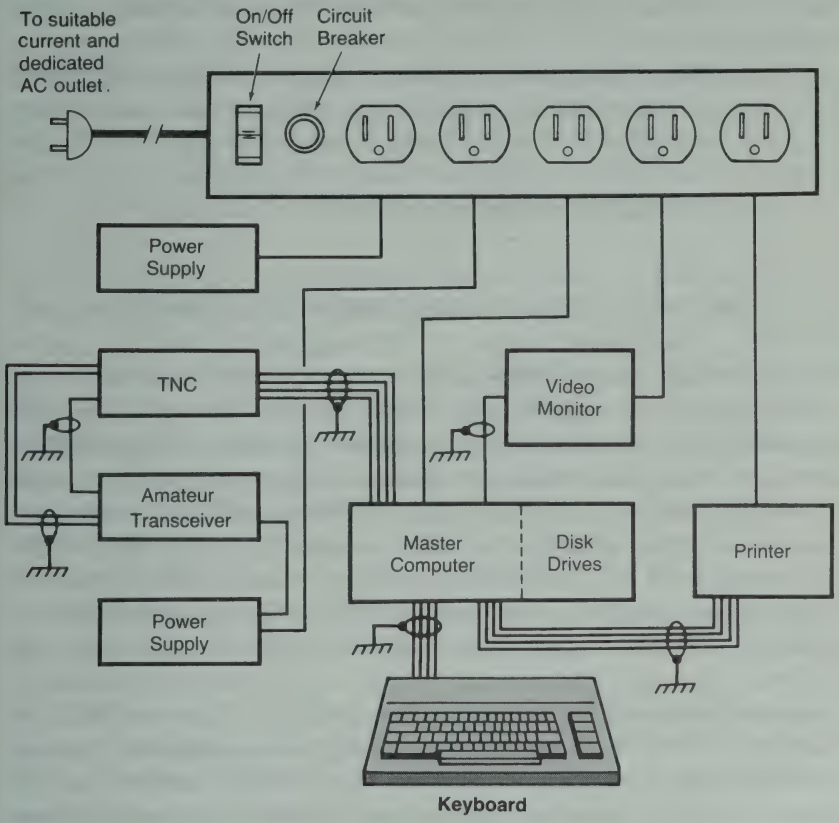


Figure 4-2. Example of wiring arrangement and component layout in a "master cabinet" type setup.

A third and unique style of personal computer terminal that can be interfaced with a packet setup is worth mentioning—the braille units for blind amateurs. This area is presently expanding at a significant rate, and it's an ideal way for handicapped amateurs to enjoy both packeting and home

computing. Most braille units include a rubberized keyboard area for data entry and a printed "display" on paper. At least one unit, the Versabraille II by Telesensory Systems of Mountain View, California, includes a real time direct "read" display using a series of raisable pins. This self-contained unit measures only 10 × 15 × 3 inches, and is available with its own terminal program and RS-232 interface. Packet radio operations merely require connecting a TNC and amateur transceiver. The operator then slides a finger across the readout area and presses a side button when information updating is desired.

Two additional computer terminals with appeal to handicapped amateurs are the Portabraille and the Pocketbraille developed by the Kentucky Department for the Blind (427 Versailles Road, Frankfort, Kentucky 40601). The Portabraille includes both braille and voice-synthesized output. The small Pocketbraille includes only synthesized output.

Interfacing Video Displays and Home Computers

Home computer systems typically use a conventional home television or a video monitor as an output display device. In fact, a channel 3 or 4 video modulator is usually included in inexpensive computers and is an optional accessory for the more deluxe computers. The modulator's output can be connected to a television's VHF antenna terminals and tuned in the same way as a regular television station's signal. It should be noted, however, that the display from a home television will not be as readable as that of a computer monitor. The baseband video output may also be available for direct connection to a monitor rather than a television. These two signals are quite different in nature and frequency ranges and can't be cross-connected. Baseband video and audio occupies a bandwidth of 30 Hz to 4 MHz and 20 Hz to 20,000 Hz respectively. After those signals are applied to a television modulator, they encompass a 6 MHz television channel spectrum near 60 MHz. Some people have unwittingly tried to connect baseband video and audio to the antenna terminals (VHF, surely) of a regular television and were perplexed why it wouldn't work. That low-frequency signal was well outside the TV's tuner and IF range. The tuner never knew a signal was present. Baseband audio and video signals are not recovered or produced until the television's detector circuits.

The opposite happens when a TV modulator's output is accidentally or unwittingly connected to the video input of a closed-circuit monitor.

A monitor differs from a television receiver in the fact it doesn't include a tuner or IF stages. Also, some deluxe modern television receivers include a separate video input which bypasses RF and IF stages. If you own a combination television receiver and video monitor, check its inputs closely before randomly connecting and hoping for successful results. When connected improperly, a 60 MHz (approximate) channel signal is applied to an input which accepts 30 Hz to 4 MHz. Since the 60 MHz RF signal is far above the monitor's input frequency range, it simply doesn't know a signal is being applied to its input. These problems can be quickly and easily sidestepped by double checking instruction manuals and pinout connections between the home computer and its display unit.

Internal Architecture of Home Computers

In several respects, the typical home computer can be visualized as a scaled down version of a large and professional computer. Its internal circuitry includes a central processing unit (CPU), an input/output section, a specific amount of "fixed" or read only memory (ROM), and a specific amount of "working" or random access memory (RAM). This arrangement is shown in Figure 4-3. All of the sections are interconnected by a 16-bit bidirectional address bus, an 8-bit bidirectional data bus, and related control bus lines. This arrangement allows the CPU to address a particular memory location, I/O port, etc., enable that location with a control pulse, then move its information between sections connected to the data bus lines. These actions also include performing special CPU operations on associated data. Although only one I/O port is shown in Figure 4-3, several are usually included in a computer.

As a simplified means of visualizing overall operations, let's draw an analogy between a computer system and a small auto service center in which one person (our CPU) acts as both kingpin and master mechanic. The constant input/output flow of vehicles is too rapid and chaotic for "fixed while you wait" actions, so a storage area (RAM) provides time buffering during operations. The mechanic doesn't know anything, but every needed item and detail is readily available (in ROM). All service sections and the mechanic work at near light speed. Notice the prime factor here is speed—the faster the system works, the more functions and quantity of autos or data it can handle.

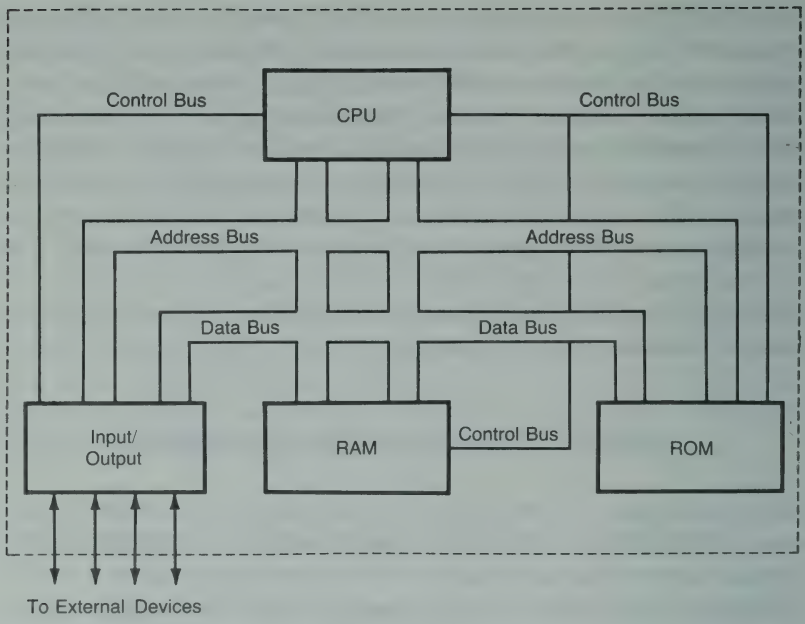


Figure 4-3. Block diagram of a typical home computer.

A day's activity begins. The mechanic/CPU queries/addresses ROM (what shall I do?). Its data bus issues a directive: open front doors (I/O) and input a fixed amount of traffic to RAM storage. Next, the mechanic/CPU is directed again by ROM to move some autos/data from RAM to CPU. The necessary operations are performed sequentially through a complex series of internal CPU actions. Some of those operations again require communication between the CPU and RAM along with frequent checks with the ROM to discern how such operations are performed. Processed work data is also temporarily retained in RAM. During that same time, additional autos/data continuously appearing at input/output doors are also directed by the mechanic/CPU into RAM storage. Likewise, processed autos/data in RAM storage are directed to the I/O port when requested, and output to the external world. Assuming we make a couple of minor modifications, we can say that activities of a quite similar nature (although electronic rather than physical) occur inside every home computer. The necessary changes involve separating the RAM into two sections, with the additional section holding the CPU's directions regarding "what it is" (in the analogy a mechanic) and "what

it does" (service cars or process information). The ROM is then filled with common sense or functional information which the CPU also needs for survival. Using this arrangement, we could input new information to the RAM (with the CPU's direction, naturally), and change the auto service center to any other one man operation imaginable. Basic survival information is still in ROM; we merely change the RAM through the facilities of an external knowledge bank (a computer's disk drive or game cartridge, etc.). Let's now delve slightly deeper into the home computer's internal sections and their data processing functions.

A computer's true heart is its CPU (see Figure 4-4). This section, which is usually included within a single chip, even has its own heartbeat to which all other sections are slaved: an internal clock or crystal controlled oscillator. All data within the computer moves in step with these clocked pulses. A built-in set of operating instructions, or microcode, is also included in the CPU. Inside the CPU, there is an arithmetic logic unit (ALU), a timing and control unit (CU), plus several registers for temporarily holding instructions and data during operations. Those operations begin when the program counter moves to the address register's beginning. The specified address is called for via the address bus lines, fetched from external memory (RAM), and moved through the CPU's data bus latch, and placed in the instruction register. After decoding and consequent setup of the ALU and accumulator to execute the prescribed instruction, actual data is fetched and directed to those registers. After their action has been executed, processed data moves back through the data bus latch and on to a specified location in external memory (RAM). The program counter is then incremented by one, the next instruction's address is fetched from the external memory, and the cycle is repeated.

A home computer is of little value if it cannot properly communicate with the outside world, thus a special input/output (I/O) section is utilized. I/O devices are typically known as peripheral interface adapters, or PIAs. These ICs are bidirectional devices, and they include small buffers for retaining minimum amounts of data during an I/O operation. This provision allows the PIA to input in serial form and output in parallel form. A data direction register within the PIA determines whether an input or an output function will take place. It, in turn, is controlled by the CPU's external control lines. The PIA appears as a memory location to the CPU, hence its data can be called for via the CPU's external address bus (and the data then moves along the data bus to wherever the CPU designates). A home computer's external peripherals (such as disk drives, modems, packet radio terminals,

etc.) connect via PIAs. Since those PIAs look like simple memory locations (with ever changing data, of course), several PIAs can be connected to one CPU.

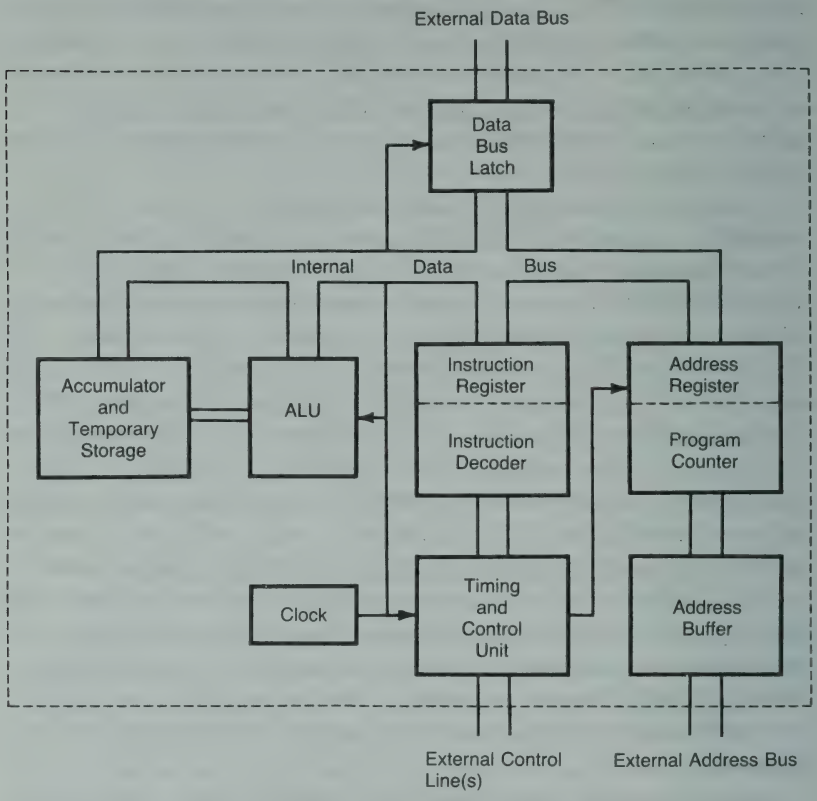


Figure 4-4. Block diagram of a CPU.

As previously mentioned, there are two basic forms of memory in a home computer—RAM and ROM. RAM typically is arranged in an array equalling 64K, 128K, 256K, or 640K bytes, and any single location within the array can be addressed directly by the CPU. This situation also holds true for ROM, thus each could be visualized as an electronic form of mail "pigeon holes." There are some distinct differences between RAM and ROM, however. RAM is a computer's working memory—a group of pigeon holes to place everything during actual operations. It's like working at a clean desk—only one thing at a time receives processing and everything else stays

in its pigeon hole. When power is removed from RAM and/or its computer, the RAM's information is lost (all pigeon holes are cleared until next time's use). ROM, however, permanently stores its information. This pigeon-holed data may be read at any time—its information always remains intact. Now we'll make a slight amendment to that statement to include programmable erasable read-only memory chips, or PROMs. These special ICs can be programmed through some special means, and thereafter the chips act like ROMs. That is, they hold their original programming after operating voltages are removed. Early PROMs were "burned" with information using ultraviolet light and an opaque window over the IC to prevent information loss while permitting reprogramming. Recent innovations in this area, including newer style nonvolatile random access memory (NOVRAM), now provide easy reprogramming of these fixed memories from an interconnected keyboard. Several manufacturers are presently including NOVRAM or equivalent-type PROMs in their packet radio TNCs. The devices retain all popular packet operating parameters, but they can be readily changed as desired right from a setup's keyboard. These devices are quite beneficial, especially when considering that future changes require merely modifying software rather than hardware.

Looking back at the overall home computer concept, we realize a unit's CPU acts as both a master traffic controller and a special functions executor. This CPU "sees" all external devices (outside the CPU but within the computer) as memory locations. Moving, examining, and acting on that information are the CPU's prime functions. We should also understand that in order to conserve precious milliseconds, data movement *inside* a computer is in parallel form (a separate wire for each data bit, allowing "single word steps" with each clock pulse). *Outside* the computer, data normally moves in serial form (one data bit behind the other, each taking one step forward with each CPU-generated clock pulse).

The Computer's Role in Packet Radio Systems

Although a home computer is quite capable of performing vast numbers of mathematical calculations, that ability isn't a prerequisite for packet radio operations. The computer, however, must be capable of accomplishing a substantial amount of data processing within the fastest possible time. So the CPU's prime function is overseeing data movements while continuously checking that data for special characters which signify additional actions

are required. Essentially, this job can be narrowed down to continuously checking the I/O port to determine if there is any incoming data, checking the keyboard for outgoing data, evaluating that data for special characters, placing data in appropriate memory/buffers, and assembling various data "pieces" into a packetable form. This process calls for programming the computer with the appropriate software to function as a general data communications terminal with telephone modem-type interface capabilities.

There are several styles and varieties of terminal software available for most home computers to suit everyone's needs. They range from simple "twelve liners" which can be entered from the keyboard into systems lacking support peripherals to elaborate disk-loaded programs. The more sophisticated a program is, the more special features and extra buffer benefits it has. The main things to look for in terminal software are ease of use and compatibility with your computer. Likewise, the main features to look for in a home computer for packet radio are full ASCII character sets, RS-232 port capability, and serial interfacing. The overall idea here is quite simple: we'll merely interface our computer/terminal to a TNC using its serial output RS-232 port, and that function will be specified in its terminal software.

The previous statements may have inspired some clever thinking among creative minded amateurs. Might it be possible to adapt an inexpensive or surplus communications terminal for packet radio needs? Why not, we think, since the terminal only needs to interface with the TNC, handle serial data flow in a speed range compatible with the TNC, and utilize the full ASCII character set. It sounds as if we merely substitute a TNC for the surplus unit's telephone modem, and we're ready for packeteering. That's quite possibly true, but let's not allow our enthusiasm to override our accurate vision. Remember both data levels and speeds between the terminal and TNC must be identical. *Don't assume that. Check and confirm it!* Also, you must ensure the terminal is indeed a "dumb" rather than "intelligent" unit. Many terminals intended for or pulled from commercial service include their own dedicated-use program in ROM. Therefore, they will function only within that realm, although they're ASCII and RS-232 ready. Modifying those units by replacing their ROM with "basic terminal" equivalents can prove a challenging experience, and may not be worth the efffort. That situation is especially true if all manuals and information on the terminal can't be secured. Understand, also, the final results of such endeavors may produce only a pure "bare bones" terminal without internal storage or buffers. Sometimes one can find a bargain, but usually it's more reasonable to simply purchase an inexpensive home computer. That final decision lies with each individual amateur.

Overview of Popular Home Computers for Packet Radio

The home computer market is changing and expanding continuously. Although not meant in a derogatory manner, you can almost bet that whatever unit or system you purchase today will be superseded in the near future by a better model. There is no real need for concern, however, as older systems still perform as well as they did when new, and packet communications work equally well on new or old computers. The other operators never know what type computer you're using unless you tell them. Some of the traditionally popular home computers include Radio Shack's series, Commodore's 64, and Atari units. The popular new style computers include Apple IIs, Macintosh, IBM PC, and their many clones.

When initially considering the purchase of a home computer system, try to be logical in your evaluations and visualize both present and future needs. Make notes of your thoughts, let those notes settle a few days, then review them from a different viewpoint. Is the computer proven, reliable, supported by sufficient software, expandable, easy to use, and (a very important point), operator friendly? Finally, there's the computer's personal appeal and keyboard feel. If a unit suits your needs, fits your desires, and its keyboard has a good touch, go for it. The end result will surely be a friendly computing companion you'll enjoy for a long time. Now let's take a closer look at some of today's popular home computers.

Leading our review is the popular Commodore 64—so designated because of its 64K bytes of internal memory. The Commodore 64 is shown in Figure 4-5. This unit has been in existence several years, and is a popular item in amateur setups throughout the land. The computer survived several rumors of discontinued manufacturing, but it continues to show up on bargain shelves and in discount stores nationwide. Both baseband video and modulated RF output are available and a wide variety of software can be plugged into its rear game port. A mating disk drive, cassette tape deck, and printer (each with its own special connector) are available for the C64. The C64's telephone modem plugs directly into a board edge connector, then the telephone's handset plugs into the modem, so it's obviously not RS-232 or universal TNC compatible. No problem, however, as both Commodore and several other manufacturers produce adapters for the C64 that interface edge connector to RS-232 with a DIN-25 plug. Alternately, AEA produces an outstanding TNC which merely plugs into the C64's game port. It's difficult to predict when the C64 will fall from popularity, but the odds of a comparable (and fully compatible) replacement are quite high. Possibly the C128 is a step in that direction.

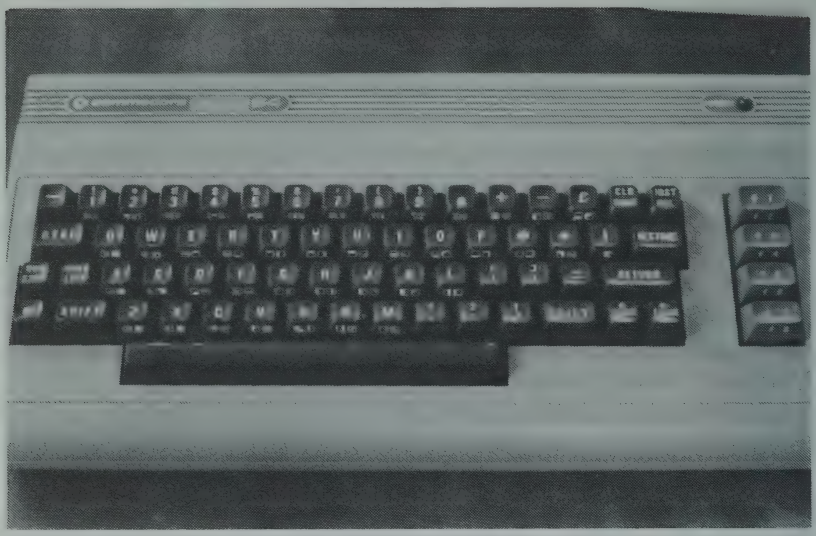


Figure 4-5. The Commodore 64 home computer.

Radio Shack's home computer systems recently diverged in a couple of quite interesting directions. One faction continued their production of inexpensive home computers while the other took a more professional, IBM-compatible direction. The result provides substantial end user flexibility. Since either form of Radio Shack computer can be RS-232 interfaced, either one can be used for packet radio setups.

Radio Shack's present IBM-compatible system, the model 1000SX, is shown along with its optional video monitor, printer, and computer desk in Figure 4-6. The computer employs the modern design of a master cabinet containing all electronics and dual floppy disk drives, a separate keyboard, and several styles of plug-in monitors. Likewise, several styles of printers are available for this system.

The 1000SX includes 384K of memory, five expandable card slots, and built-in adapters for black and white or color monitors. An RS-232 adapter is presently optional. The 1000SX is supported by a full line of Radio Shack software. For more information, see your local Radio Shack dealer.

The widespread acceptance and mass popularity of IBM's PC-XT professional home computer kindled an unbelievably large market of IBM "clones." These copies are presently appearing at hamfests and are being advertised in electronics magazines worldwide. The IBM clones are extremely popular because of their low cost and ease of assembly requiring

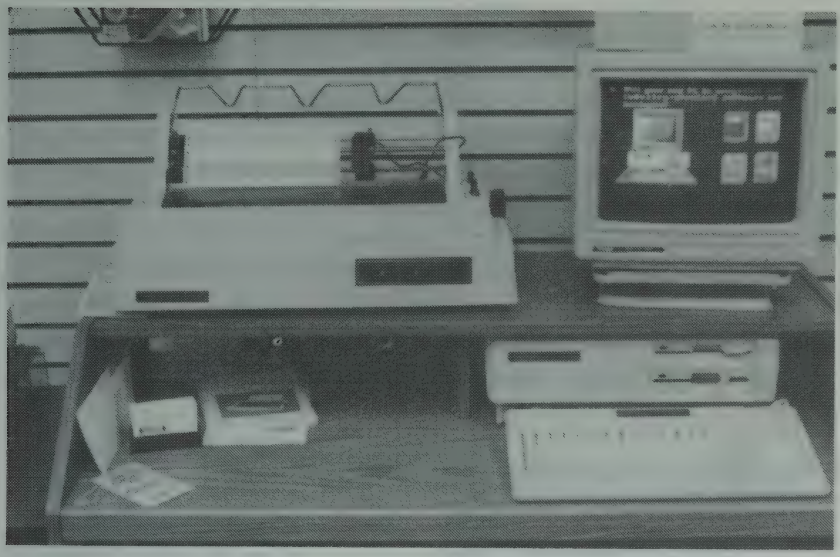


Figure 4-6. Radio Shack's Model 1000SX home computer system.

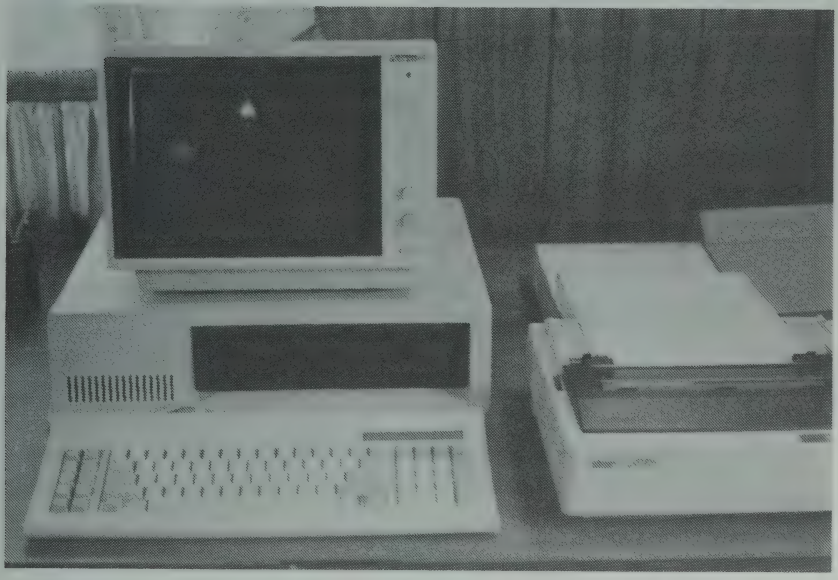


Figure 4-7. An assembled IBM PC clone system ready for action.

only two hands and a screwdriver. They may be sold in individual pieces—AC supply, motherboard, CPU board RAM board, controller board, disk drives, and cabinet—or you can buy them fully assembled. One then adds

your own preferred keyboard, monitor, printer, and internal boards to create a deluxe finished system that typically looks like the system shown in Figure 4-7. This system, incidentally, was assembled from individual parts in only a couple of hours. Everything plugged in and screwed down. Moving the monitor sitting atop the clone and lifting its lid (see Figure 4-8) reveals a clean and efficient layout. The disk drives are complete and simply slide into place and plug into sockets. The AC supply's fan cools the complete unit. Several extra sockets are available for expanding memory from 256K to 640K, and card sockets are provided for color graphics, RS-232/modem connectors, etc. Locating IBM clones at competitive prices involves shopping computerfests and related magazines. Good hunting and good luck in finding your own personally appealing home computer.

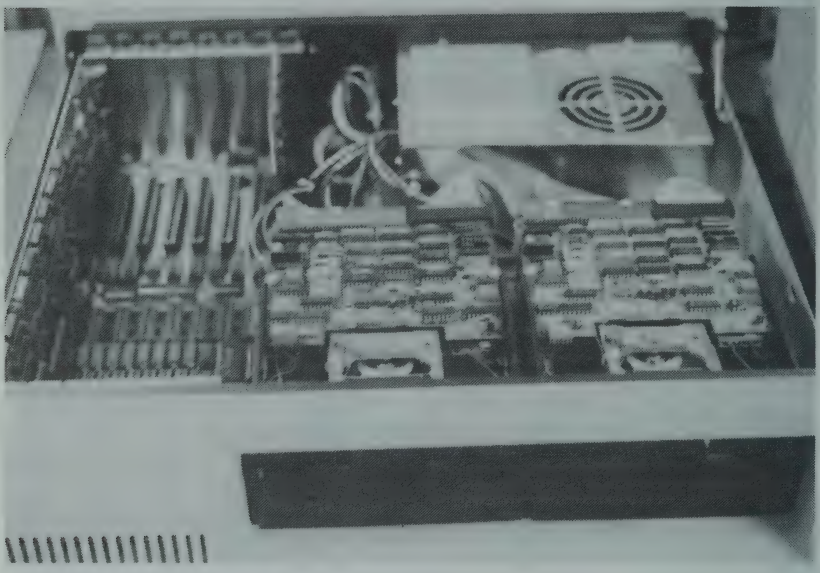


Figure 4-8. Inside view of the IBM PC clone.

Summary

The home computer market is growing by leaps and bounds, and the computer continues to be refined into a professional tool rather than being just an entertaining toy. This situation is illustrated by recent changes in physical structures. Modern computers are becoming large boxes with

internal disk drives and AC supplies. Keyboards are taking on the feel of professional typewriters, and internal add-ons are the trend of the day.

An elaborate home computer isn't necessary for enjoying packet radio activity. If that application is one's sole interest, a simple and inexpensive computer (that will interface with your TNC) is suggested. If additional home computing is desired and you don't object to shared applications, however, a professional style home computer can be quite attractive. Study your own needs and finances, then purchase accordingly.

Survey of Amateur Equipment for Packet Radio

As pointed out in previous chapters, packet radio's unlimited capabilities and overwhelming popularity continue attracting enthusiastic amateurs. Unlike many new or specialized areas of amateur radio interest, however, packet is supported by a wide selection of commercially manufactured gear. This equipment ranges from basic and inexpensive units to highly sophisticated and truly deluxe items with every special feature one could ever imagine. It's an absolutely fantastic situation, and packet radio is still in its early growth stage. We might also point out the mass production of packet radio equipment and support items has resulted in very competitive market prices. So after one acquires a general background, subsequent questions typically involve equipment selections. In fact, that may be why you purchased this book—to find the gear best suited to your needs. This chapter, then, will take a detailed look in the direction of presently popular packet radio equipment and support items.

Please bear in mind that more and more manufacturers are joining this field each day, and inclusion of *all* available gear is simply impossible. We would never reach a printing stage, and the book's size would become enormous. This does not in any way signify our endorsement of some units over others. We merely have limited space along with a specific publishing frame, and the highlighted manufacturers responded promptly to our inquiries. This chapter's views and reviews section provides you with a present day overview and criteria which can be used to evaluate and compare both existing and future packet radio gear. As you follow along with us, you'll recognize both similarities and differences in various units. Not only will this prove beneficial for considering units manufactured after this book's publication, it will also give you some helpful ideas for creating your own smooth operating packet radio setup.

One important aspect that shouldn't be overlooked by packeteers considering new equipment is overall station compatibility. This point means ensuring all items will work in tandem to create a packet station. Data signal levels and speeds between one's computer and TNC, and the means for setting those variables are prime considerations. Some TNCs include convenient microswitch selections, and some do not. Availability of interconnecting cables and connectors is another important point. New computers and amateur transceivers often reach dealer shelves several weeks or months before accessories such as mating microphone or input/output plugs are available. Their proud new owner might then be forced into makeshift plugs or connectors. Check needed accessories when you buy main items. Don't be held back by a single necessary link. Likewise, think ahead in your needs. Will your planned VHF-compatible items be suitable for future HF or higher speed packet operations? Should you also consider RTTY and CW in those plans, or would a separate new setup for those later operations prove more attractive? Is there an easy way to interface transmit/AFSK signals? Can their transmit level be adjusted conveniently? Remember different audio tones are employed for packet than RTTY. *Do not* use a deluxe HF or VHF transceiver's built-in FSK oscillator or modulator for packet. Its tones and frequency shifts are incorrect. Direct packet radio tones to a transceiver's audio input; that is, the microphone or, preferably for VHF/FM units, the deviation control or tone pad input. That stage is located electrically after the microphone gain control, and sidesteps square-wave distortions from overdrive. You can then control packet modulation level from the TNC's modem potentiometer. Visualize how everything connects and adjust before purchasing, and you'll be right on track for success. Since our previous chapter included an overview of presently popular home computers, let's now *briefly* review the amateur transceiver and antenna scene as they relate to packet radio. Then we'll turn our attention toward the thriving TNC market.

Packet Transceivers and Antennas

As most radio amateurs are aware, our present market of VHF and HF, FM and SSB transceivers consists primarily of imported gear packed with features. This is especially evident in the area of 2-meter frequency synthesized units, with newer and more exciting equipment appearing every few

months. Since 2 meters is the main area of packet radio activity we thus have an endless selection of FM transceivers to fit every preference.

Older model VHF transceivers are attractive for packet in the sense that they represent a minimum financial investment and can be dedicated for packet use in a casual manner. One's newer model and more deluxe VHF FM transceiver can then be free for mobile or home station use as desired. While such ideas make sense, we don't advise going too far back in time with packet transceiver selections. Exceptionally old model FM transceivers used slowly operating mechanical TR relays with related long delays for transmitter and receiver stabilization during operation. Newer model VHF FM transceivers include solid-state switches with resultant fast recovery time. It's true that older rig delays can be somewhat sidestepped with a TNC's TXDELAY parameter for packet transmission, but there simply isn't an easy way to compensate for slow receiver recovery time. Throughput of large VHF networks can be crippled by a slowly responding station. Visualize, as an example, a packet setup's TNC performing like a sharply tuned DX operator with full break-in capability. It's listening for important activity every nanosecond it isn't transmitting, and the first parts of messages can occur at any time. Missing that first part of a packet means missing the whole packet. Slow receiver recovery can create a round robin of "miss" and "say again" episodes which delays communications among all on-frequency stations. Next, visualize the previous example with all VHF network users operating modern transceivers with noticeably fast TR switching and PLL stabilization times. Each station operates rapidly and efficiently on a single frequency, resulting in the maximum possible number of message exchanges. Packets are "ACKed" the first time, TNC-foreseeable collisions are minimized, and throughput ratios are encouragingly high. New design transceivers are indeed a good packet investment worthy of consideration.

The first major transceiver manufacturer to address the packet radio market with a compact VHF FM unit was Icom. Introduced in 1986, their IC-28A (25-watts output) and IC-28H (45-watts output) include two especially attractive features worth mentioning. Their extended frequency coverage of 138 to 174 MHz provides direct reception of continuous nationwide NOAA weather broadcasts in the 162.550 MHz range. Second, their exceptionally fast TR switching and PLL stabilization is ideally suited for busy VHF packet network use. The FM transceiver measures only 2″ × 5½″ × 7¼″ (H × W × D), allowing it to fit into even the tightest space, and its easy-to-understand controls are quite user-friendly. This unit is shown in Figure 5-1. The transceiver's large LCD readout includes an automatic dimming

backlight to fit various environments, and frequency or memory selection is available from the main tuning knob or microphone as desired. Internally, the IC-28A/H features twenty-one programmable memories, band or memory scan selection, of all popular subaudible tones, and superb overall circuit designs. The IC-28A/H is presently one of the most popular transceivers in the VHF FM market.

Figure 5-1. The Icom IC-28A/H VHF 2-meter FM transceiver.
(Courtesy Icom America, Inc.)

Another very attractive Icom VHF FM transceiver is the IC-27A/H of Figure 5-2. This unit features dual VFOs and eight programmable memories which can be tuned by the main knob or microphone, thirty-two internal PL tones, four modes of programmable scanning, plus an optional speech synthesizer for frequency announcements. This unit's internal circuits, and especially its quite selective receiver, provide superb performance under even the most difficult circumstances. The unit measures only 1½″ × 5½″ × 7″, making it one of today's most compact VHF units. Additional information is available from Icom America, Inc., 2380 116th Avenue, N.E., Bellevue, WA 98004.

Kenwood's most recent entry in the VHF FM market is the TM-2570/2550/2530 series of transceivers which boast 70-, 45-, and 25-watt output respectively. This unit is shown in Figure 5-3. These units cover 142 to 149 MHz, with twenty-three programmable memories, large LCD readout and two types of band or memory scanning. Frequency selection is via the front panel keypad rather than the main knob; however, band or memory tuning can be accomplished with the microphone's up/down buttons.

Figure 5-2. The Icom IC-27A/H 2-meter FM transceiver.
(Courtesy Icom America, Inc.)

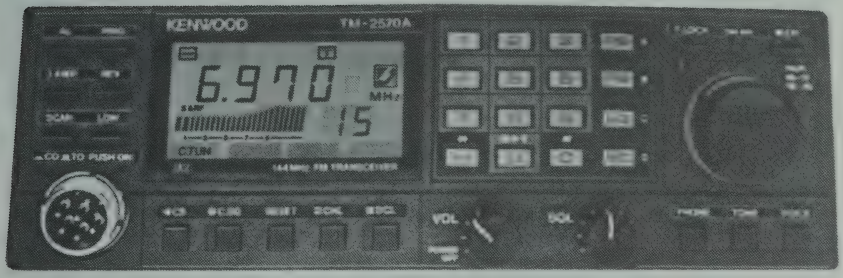


Figure 5-3. The Kenwood TM-2570 and TM-2530 FM transceiver.

The front keypad also serves as an autopatch DTMF (dual tone multi-frequency) encoder during transmit. A seven-digit autodialer that can store up to 15 telephone numbers is also featured. While seven digits won't allow enough storage for a repeater's autopatching access codes, other autodialing memories can be mixed or combined to provide that capability by simply pushing two buttons. While 70 watts may seem an overkill for packet operation (25 watts is usually quite sufficient), it's a reassuring "trump card" for packeteers in remote locations or late night highway travelers (so there's

a double use here—mobile and fixed/portable packeting). A low-power switch is also found on the front panel. Additional information on all Kenwood items is available from Kenwood U.S.A. Corp., 2201 E. Dominguez St., Long Beach, CA 90810.

Yaesu's most recent 2-meter FM transceiver is the FT-270RH—a 45-watt output unit of exceptionally small dimensions (Figure 5-4). Measuring 2″ × 6″ × 7″, the FT-270RH includes dual VFOs and ten programmable memories. Band scanning with programmable upper and lower limits is provided, along with priority channel operation which is nice for true packet devotees. An optional voice synthesizer is available for announcing the operating frequency. This transceiver is quite deluxe, yet it's easy to understand and operate. Additional information on all Yaesu products is available from Yaesu USA, 17210 Edwards Rd., Cerritos, CA 90701.

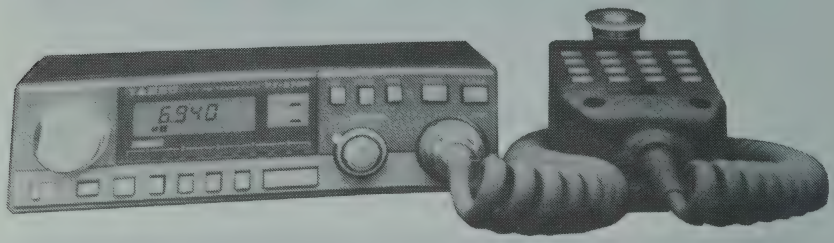


Figure 5-4. The Yaesu FT-270RH 45-watt 2-meter FM transceiver.
(Courtesy Yaesu USA)

Another very popular 2-meter FM transceiver is Azden's PCS-5000 (Figure 5-5) which features direct keyboard frequency entry and up/down tuning or scanning from its microphone. The unit covers 140 to 153 MHz with twenty programmable memories in two separate banks. Both the LCD readout and the keypad are backlit, creating a very impressive looking unit which should complement any packet setup. For more information, contact Amateur Wholesale Electronics, 8817 S.W. 129th Terrace, Miami, FL 33176.

A full listing of all presently available amateur VHF (and HF) transceivers is obviously far beyond the scope of this book. This overview, however, should provide sufficient insight and incentive for further investigations in current magazines. We thus encourage your continuing investigations through the advertisement sections of *CQ*, *QST*, *73*, *Ham Radio*, and *Worldradio* magazines, plus hands on exposure at dealers and hamfests.

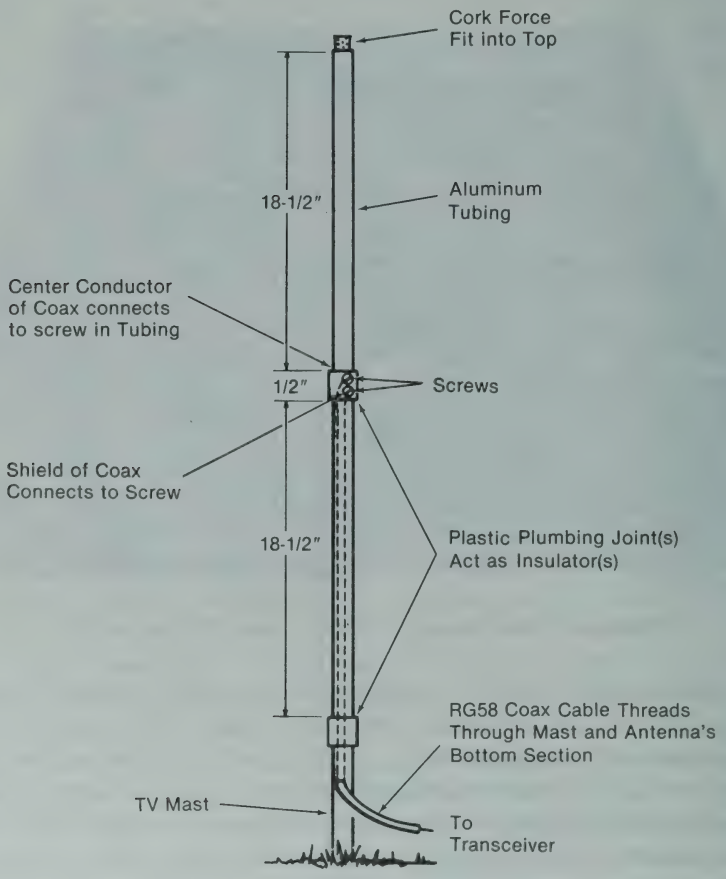
Although packet newcomers may think at first that they'll need large high-gain antennas for serious operating, that isn't necessarily true. Unless

one lives in an isolated or remote area, their main concern about RF involves getting respectable signals to and from nearby digipeaters. That simple action puts one in touch with local and possibly long-distance networks, which is packet's most popular attraction. Not only are high-gain antennas an extravagance, they may radiate one's packet signals into distant digipeaters or other networks and create unnecessary on-frequency confusion. We thus advise checking your own situation before deciding on a particular antenna type. A basic ¼-, ½-, or ⅝-wave vertical may indeed prove optimum for packet operations while a multielement beam will be perfect for SSB DXing.

Figure 5-5. The Azden PCS-5000 2-meter FM transceiver.

One example of a basic yet efficient 2-meter vertical antenna which can be easily constructed at home in little time is illustrated in Figure 5-6. Its omnidirectional radiation pattern is ideal for fixed-station use. The antenna elements may be constructed of small diameter aluminum tubing for self-supporting fixed-station use (Figure 5-6A), or assembled solely from wire components for rollup, portable use (Figure 5-6B). The main requirement is ensuring that the coax feedline passes through the bottom element (rather than being placed beside it) to avoid radiation pattern distortions and signal losses. If the antenna is assembled in flexible, wire form and a length of

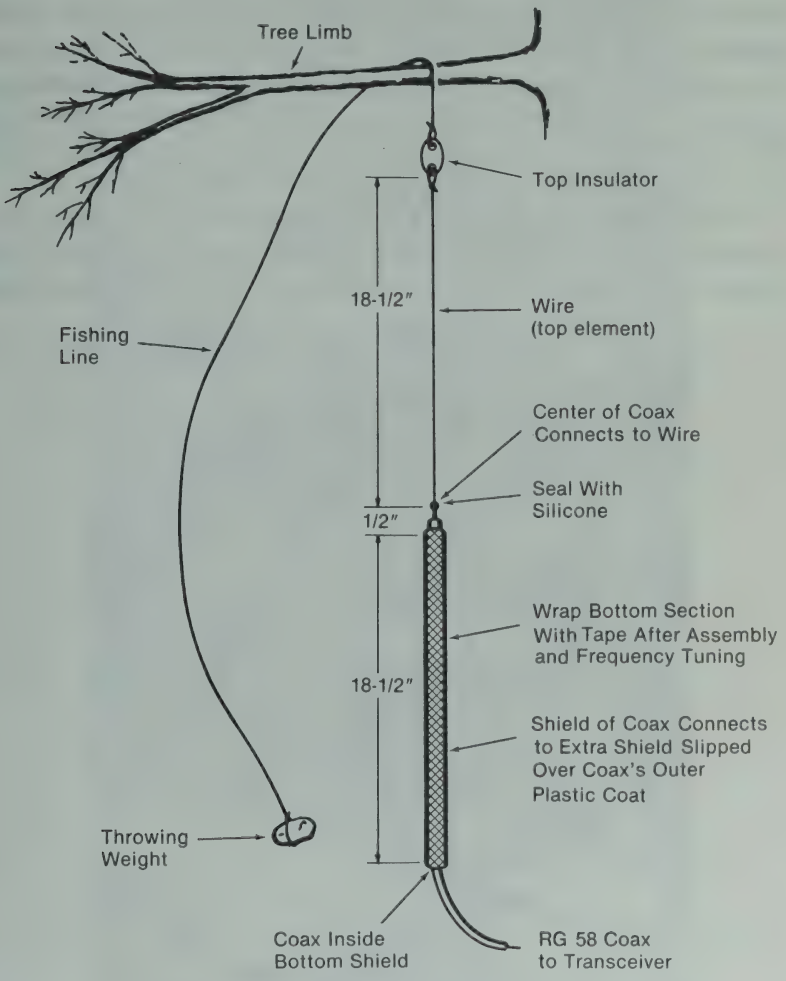
lightweight fishing line is tied to the upper section, it can be hung from any available support quite conveniently. Likewise, a small fishing weight and slingshot can zip that fishing line over a high tree limb with little effort or trouble. The easiest way to assemble the flexible antenna's bottom section is to slide a larger braid or shield over the coax feedline. If you use a short section of RG8-stripped braid, for example, it easily slides over RG58 cable. The RG58's length should be kept as short as possible, however, since its losses at 145 MHz are rather high. Feedline lengths no more than 20 feet are suggested.



(A) Rigid version for fixed station use.

Figure 5-6. A basic yet

Looking at the preassembled models there are several commercially manufactured 2-meter vertical antennas available that boast high performance and long life. AEA's Isopole and Isopole, Jr. are quite popular, and their advertisements that claim they're the ideal omnidirectional packet antenna can be supported. The Isopole's compact and lightweight design features



(B) Flexible rollup design for portable use.

effective 2-meter antenna.

an aluminum half-wave decoupling cone on its bottom section and an impedance matched half-wave upper section. The decoupling cone serves a double purpose in minimizing reception of computer generated hash while preventing feedline radiation which could lock up a computer (see Figure 5-7). Installation consists of slipping the coax feedline through a support mast (an inexpensive TV mast works fine), sliding the decoupling cone over the mast and tightening its clamp (two decoupling cones are stacked in the Isopole—one cone is used in the Isopole Jr). The coax connector is then plugged into the upper section which is slipped over the top of the mast and secured with three set screws. Although the Isopole is broadbanded, the upper section is adjustable for varying center frequency or minimizing SWR (standing-wave ratio). Additional information is available from AEA, Inc., P. O. Box C-2160, Lynnwood, WA 98036-0918.

Another popular style and series of omnidirectional 2-meter antennas are Cushcraft's classic Ringo and Ringo Ranger II (see Figure 5-8). These antennas can be assembled quickly and easily, and their compact size blends

Figure 5-7. AEA's popular 2-meter Isopole antenna.

smoothly with any environment. Several radiating sections are electrically phased to provide high-gain and low-angle radiation for both local and distant operation. For more information, contact Cushcraft Corp., 48 Perimeter Road, P. O. Box 4680, Manchester, NH 03108.

Figure 5-8. Cushcraft's classic Ringo 2-meter antenna.

The J-pole antenna is a long time favorite item among many amateurs and KLM/Mirage is reproducing a modern version of that classic antenna with their JV2X (see Figure 5-9). This ready-to-install 2-meter radiator slips onto a regular TV mast, accepts a PL-259 connector, and boasts up to 5 dB gain. It covers the full 2-meter band with plenty of overlap and can be

mounted in any available space. Your author used one of these antennas with his own packet radio setup while writing this book, and it performed like a champ. For more information, contact Mirage/KLM, P. O. Box 1000, Morgan Hill, CA 95037.

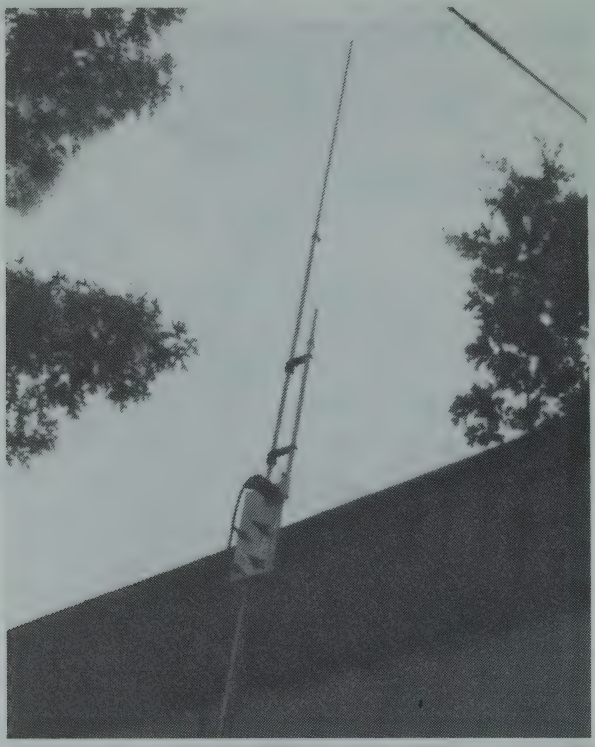


Figure 5-9. The compact and unobtrusive 2-meter J-pole antenna by KLM.

The TNC Market

Because so many people are becoming interested in packet radio, and the TNC market is growing like wildfire, the future can only be estimated roughly. Indeed, the number of TNC manufacturers and their unit sales could double (or triple?) during the months it takes for this book production. Packet radio is presently "on a roll" and there are no signs of it leveling off or declining any time soon. Therefore, we can talk about only the present.

If we "stop the clock" at mid-1985, for example, a total TNC market of approximately one million dollars is indicated. Moving the clock forward to early 1986, that figure jumps to two million dollars. Since then TNC sales have mushroomed. Fortunately, many manufacturers now offer a fascinating variety of TNCs and multimode interfacing units to radio amateurs interested in packet and computers, and the availability of units has improved. In most cases, the unit of our dreams is only a toll-free dealer phone call away. The pleasant problem then becomes making an intelligent choice. One of the best suggestions is to talk with other packeteers during group meetings, hamfests, etc., to acquire multiple opinions. Also, visit other packeteers and notice how conveniently (or inconveniently) their setups work. Finally, consider your own needs and preferences in light of what you've learned so far. Our following notes should also prove helpful in those respects.

When considering a particular TNC, always check its means of computer/terminal interfacing for system compatibility. Some units use RS-232-type serial interfacing while others include both RS-232 and TTL capability. Selection may be via PC board-mounted switches or internal jumpers. To avoid problems, check the positions of those switches or jumpers *before* connecting your computer. Remember also, our previous chapter's notes on RS-232C and DIN-25 connectors. Make sure your RS-232-looking computer and TNC are level-compatible before interconnecting them. Likewise, look over a unit's instruction manual to get an idea of that item's capability and user-friendliness. Most of today's TNC manuals are quite thick and well-documented. Some even include an instruction section on how to use the manual itself! Additional points of study include AX.25 level 2 protocol compatibility (plus V2 protocol if you're in range of Canadian networks) and inclusion of any additional protocols should they evolve during this book's printing. TNC data speeds are another point of investigation. The unit's modem output to the transceiver operates at 1200 baud for VHF activity and 300 baud for HF activity. Also, there's a recent move toward adopting 2400 baud as the usual 2-meter speed. If that trend gains a foothold during this book's printing, you'll surely want 2400-baud (or higher?) capability. As we've mentioned before, things move fast in the world of packet radio. Remember also to check data speed mating *between the TNC and its interconnected computer*. Most (but not all) present units operate at 1200, 2400, 4800, and 9600 baud. Some TNCs require operator speed selection, some automatically check for speed and sync with their host computer. Slower baud rates usually mean the TNC can't "talk to" the amateur transceiver and computer at the same time. Other items to pay attention

to include: power supplies (some include internal AC supplies and some require 12 volts DC from an external source which may or may not be included in TNC cost), the type of nonvolatile memory (NOVRAM or lithium battery-backed RAM is ideal—a burned-in PROM with one's call is difficult to loan for another's use), and modems. Most of today's TNCs include built-in modems based on the XR-2206 and XR-2211 "world chips." Some include a means of disconnecting that internal modem and connecting an external modem. This capability is worthy of consideration, as many amateur Bulletin Board Systems are accessible via both telephone and amateur HF/VHF bands. Keeping in mind the previous background information, let's take a look now at some of the currently popular TNCs and multimode units. They're quite impressive from any point of view.

AEA

Advanced Electronic Applications, Inc. was one of the first manufacturers to join the packet market, and their outstanding units continue to enjoy widespread amateur popularity. Many RTTY and computer enthusiasts remember AEA's classic CP-1 and other units described in my previous book, *RTTY Today* published by Universal Electronics, Inc. After that book was published and the packet radio craze hit full force, AEA introduced their TAPR TNC-1 clone which sold like wildfire until TNC-2s became popular.

AEA's TNC-2 licensed clone unit is the PK-80 (see Figure 5-10). Naturally, AEA included a few of their own special features in the unit for extra excitement. One such feature is improved RFI immunity so it complies with FCC Part 15 Subpart J requirements. The unit is enclosed in a rugged metal case, and rear panel DIP switches select speeds for TNC-to-computer operation (300, 1200, 2400, 4800, and 9600 baud). If a computer's speed isn't known, switch positions can be stepped until smooth operations are achieved. The PK-80's transceiver output speed is 300, 1200, or 9600 baud (an external modem is required for 9600 baud). A DIN-25 socket provides RS-232 interconnection with any RS-232-ready or RS-232 interfaced/adapted computer. One only needs to load a basic terminal program into that computer. The PK-80 supports AX.25 version 2 protocol, and its thick manual is quite extensive in explanations. It also includes details on interfacing various computers such as Radio Shack, Commodore, Apple IIs, IBM (and clones), Macintosh, and several more. Actually only three DIN-25 connections are used: transmit data (Pin 2), receive data (Pin 3), and ground (Pin 7). A power supply is not included with the PK-80; it requires an external

source capable of 12 to 15 volts DC at 400 mA. The PK-80 boasts eighty-two software commands, and its lithium-backed RAM stores user-programmed operating data such as MYCALL, etc. The unit is truly a universal packet controller in the respect it can connect to any RS-232-type computer.

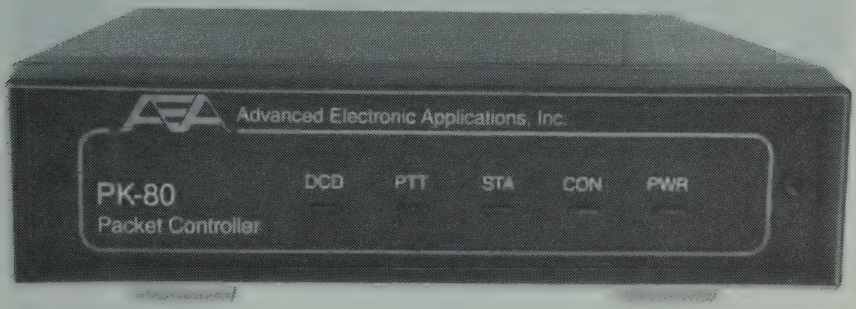


Figure 5-10. The AEA PK-80 universal-type TNC.

With the advent of increased HF packet radio operations, AEA introduced their PM-1 Packet Modem (Figure 5-11). This unit connects between any HF transceiver and TNC set for 300 baud to provide smooth operation. Why is such an adapter necessary? VHF packet signals employ two tones spaced 1000 Hz apart, namely 1200 Hz and 2200 Hz (Bell 202 modem standards). HF packet, however, uses spacing of only 200 Hz. TAPR recommends 1600 Hz and 1800 Hz for those tones. Since they modulate an SSB transmitter, however, any two tones separated by 200 Hz (such as 1700 and 1900 Hz) can be used. There's also a trend toward "wide shifts" of 600 Hz, with 1700 Hz and 2300 Hz tones being used. The PM-1 thus converts 200 Hz- or 600 Hz-shifted tones to 1000 Hz-shifted tones during receive and vice-versa during transmit. It also features elaborate dual-channel filtering for optimum selectivity, along with a critically needed tuning indicator. HF packet can't be simply tuned in while watching for good copy because any data lost during a brief "brapp brapp" disqualifies the whole packet. Interconnecting the PM-1 is a cinch (Figure 5-12), and front panel switches select VHF or HF radio operation and 200 Hz or 600 Hz HF tone shifts. This unit also requires an external 12- to 15-volt DC power supply capable of 200 mA.

One of the first feature-packed units to hit the market was AEA's multimodel PK-64—the "Pakratt." This cleverly designed and compact TNC-plus unit provides packet, RTTY, ASCII, AMTOR, and Morse operation with

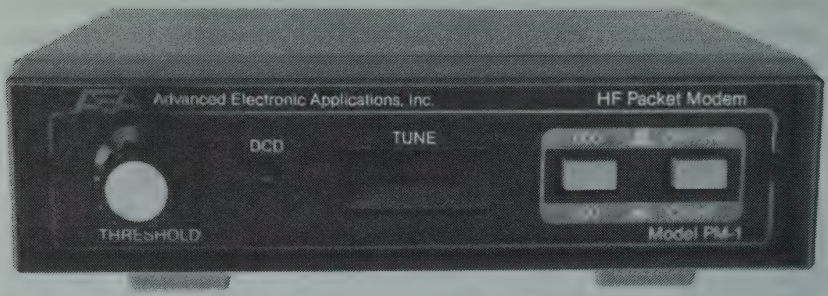


Figure 5-11. The AEA PM-1 HF modem designed to interface with any 300-baud-compatible TNC and HF transceiver for packet operations.

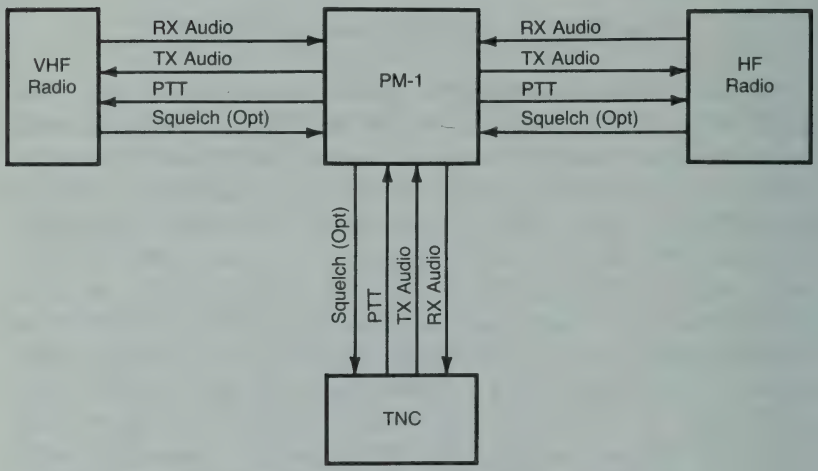


Figure 5-12. Interconnecting wiring scheme used with the AEA PM-1.

any Commodore 64 or 128 computer (see Figure 5-13). Deluxe operating software is built-in for all modes including packet, and hookup involves simply plugging the unit's multiribbon connector into a Commodore's game port. Add a VHF FM transceiver, speaker, and microphone cables (which are supplied, except for the mike plug), and you're on the air in "high style" in less than five minutes! We enjoyed operating and evaluating the Pakratt 64 quite often while writing this book, and its smooth operation was unbelievable. Using clip-lead mike connections, I moved the PK-64 between

several setups in various locations and really enjoyed operator friendly packeting. If you're a packet newcomer, if you enjoy computerized RTTY and CW, or if you presently own a Commodore 64, the PK-64 truly warrants investigation.

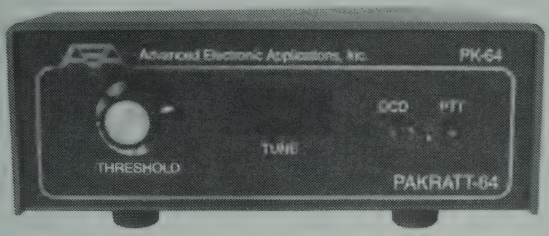


Figure 5-13. The AEA PK-64 "Pakratt."

The AEA PK-64 might be considered a complete package setup because it includes all necessary software and hardware (plus a hefty 13-volt DC supply) and an extremely well-documented instruction manual. The manual also explains packet operating techniques, includes "quick start" and "self-test" sections, and a separate section tells how to use the manual itself. Not only is the PK-64's EPROM-stored terminal program easy to understand, the operating parameters default to typically desired values yet can be easily changed at the keyboard for personal preference (Table 5-1 gives a summary of the operating commands, their default settings, and ranges). The unit supports AX.25 version 2 protocol and operates at 1200 baud for VHF or 300 baud for HF operation. Its direct Commodore connection allows the operator to get around problems such as interfacing hardware, finding a terminal program, worrying with data speeds, etc. If serious HF operations are contemplated, the PK-64's optional HFM-64 modem is also suggested. This add-on expansion includes a front panel threshold/squelch control and ten-segment LED tuning indicator plus an add-on board that installs inside the PK-64 cabinet. All you need to do is insert the board in place of a front panel spacer, cut two jumpers, plug in the HMF, and enjoy. One special attraction of the PK-64 is its connect siren. When the volume is turned up on your monitor and someone connects with you, an enthusiastic "wheoo, wheoo, wheoo" alerts you to that activity—a real attention grabber.

The PK-64's disadvantage of requiring a Commodore 64 or 128 computer has now been overcome with the super deluxe Pakratt, the PK-232. As the name implies, this AEA brainchild provides all the PK-64 capabilities (and a few new ones) to any RS-232-equipped computer. Plug that cable

Table 5-1.
Operating Commands for the AEA PK-64 Multimode TNC

Command	Default Setting	Time	Range
AUTOCR-T	0		
AUTOCR-R	80		
AUTOLF-T	Off		0–255
AUTOLF-R	Off		0–255
AX25L2V2	Off		
AXDELAY	0		
AXHANG	0		
BAND	VHF	.12	0–15
BEACON EV	0	.12	0–15
CHECK	30		
CONMSG	Off	10	0–255
CONMODE	Conv	10	0–255
CONMAX	10		
CONSTAMP	Off		
CPACTIME	Off		0–10
DAYSTAMP	Off		
DIGIPEAT	On		
DWAIT	2		
ECHO	On		
FRACK	3	.04	0–15
FULLDUP	Off		
HARDTIME	On	1	1–16
HEADERLN	On		
LCOK	On		
MAXFRAME	4		
MFILT	$0000		
MFILT	$0000		1–7
MONITOR	2		$0–7F
MONCON	Off		$0–7F
MONDIGI	Off		0–6
MONREG	Off		
MONRPT	Off		
MFROM	All		
MTO	None		
MONSTAMP	Off		
MYCALL	PK64		
PACLEN	128		
PACTIM AF	4		
PASSALL	Off		0–255
PRINTER	1	.25	0–15
PRNCMD	0		
RESPTIME	12		1–2

Table 5-1.—cont.
Operating Commands for the AEA PK-64 Multimode TNC

Command	Default Setting	Time	Range
RETRY	10		0–255
SQUELCH	Neg	.10	0–255
TXDELAY	8		0–15
UNPROTO	CQ		
WRAP	On	.04	1–16
XMITOK	On		
RTTY:			
AUTO-CR	On		
AUTO-LF	On		
ARQTMO	45		
SELCAL			
USOS	On	1	1–255
WIDESHIFT	Off		
WORDOUT	On		
XMITREV	Off		

into the PK-232, initialize a communications/terminal program, and start enjoying packet, RTTY, ASCII, AMTOR, and CW on VHF or HF. It's that easy. The same operator interface is used on each mode. Learn one and you've learned them all. Modems and speeds change automatically as you change modes, and automatic Morse speed copying is included. The unit also automatically checks and sets its computer data speed at 300, 1200, 2400, 4800, or 9600 baud. You simply connect and enjoy. An external telephone modem for BBS use can be connected to the PK-232 if desired, and there's a front panel threshold and tuning indicator, as well as rear panel jacks that provide scope outputs. The PK-232's internal software (16K of RAM, 48K of ROM, Z-80 microprocessor, and Zilog 8530 HDLC) provides an unbelievable array of operating commands and capabilities (see Table 5-2). The PK-232 requires an external power supply capable of 13 volts DC at almost one ampere. Note this is above "wall adapter" ratings, so use a suitable (stout) supply. For more information on all AEA units, contact Advanced Electronic Applications, Inc., P. O. Box C-2160, Lynnwood, WA 98036.

GLB

Another well-known manufacturer in the packet world, GLB, offers several TNCs to suit everyone's needs. These items include the PK-1 (a unit supporting Canadian and early AX.25 version 1 protocols), the TNC-2A

Table 5-2.
Operating Commands for the AEA PK-232 Multimode TNC

Command	Default Setting	Function
ALIST	Empty; Enter SELCAL	Start AMTOR ARQ "Listen" Mode
AMTOR	Immediate Command	Start AMTOR Mode in ARQ Standby
ARQ	Empty; Enter SELCAL	Start AMTOR ARQ Call With SELCAL
ASCII	Immediate Command	Start ASCII RTTY Mode
AWLEN	7	Data Bits Per Word, to Terminal
AX25L2V2	Off	Operate as AX.25 Version 1.0
AXDELAY	0 (Zero)	Repeater Key-Up Delay (×10 ms)
AXHANG	0 (zero)	Repeater Hang Time (×10 ms)
BAUDOT	Immediate Command	Start Baudot RTTY Mode
BEACON	Every 0	Set Beacon Timing (×10 s)
BKONDEL	On	Send BS SP BS for Delete Char.
BTEXT	(Sample Text)	120-Byte Beacon Message Text
CALIBRA	Immediate Command	Start Calibrate Mode
CANLINE	$18 <CTRL-X>	Line Delete Character
CANPAC	$19 <CTRL-Y>	Packet Delete Character
CCITT	On	Select CCITT ITA#2 or US Baudot
CFROM	Empty; Enter Callsigns	Reject Connect Requests From
CHCALL	Off	Show Callsign After Channel ID
CHDOUBLE	Off	Show CHSWITCH Character Twice
CHECK	30	Idle Link Timeout (×10 s)
CHSWITCH	$7C <|>	Channel-Select (Link) Character
CMDTIME	1	Transparent Mode Escape Timer
CMSG	Off	Send CTEXT Message to Caller
COMMAND	$03 <CTRL-C>	Character Escape to Command Mode
CONMODE	CONVERS	Mode to Enter When Link Starts
CONNECT	Immediate Command	Send Connect Request to <CALL>
CONPERM	Off	Never Disconnect This Link
CONSTAMP	Off	Mark Connections with Time/Date
CONVERS	Immediate Command	Start Converse Mode From Command
CPACTIME	Off	Use Packet Timeout in Converse
CRADD	Off	Allow <CR><CR><LF> in RTTY Modes
CREJ	On	Reject Callers Listed in CFROM
CSTATUS	Immediate Command	Show Status of Channels (Links)
CTEXT	(Sample Text)	120-Byte Connect Message Text
CWID	$06 <CTRL-F>	Command to Send CWID (in Text)
DAYSTAMP	Off	Include Date in Time-Stamp
DAYTIME	None	Set/Read PK-232 Internal Clock
DELETE	Off	Use BS ($08), Not Del ($7F)
DFROM	Empty; Enter Callsigns	Digipeat These Callsigns Only
DISCONNE	Immediate Command	Send Disc to Distant Station

Table 5-2.—cont.
Operating Commands for the AEA PK-232 Multimode TNC

Command	Default Setting	Function
DISPLAY	Immediate Command	Show PK-232 Parameters/Classes
DREJ	On	Don't Digipeat DFROM Callsigns
DWAIT	16	Delay for Digi Repeat (×10 ms)
EAS	Off	Echo as Sent, Nonpacket Modes
ECHO	On	Echo Typed Keyboard Characters
ESCAPE	Off	Send ESC Character $1B AS $24
FEC	Immediate Command	Start AMTOR FEC Transmission
FLOW	On	Stop Echo to Screen While Typing
FRACK	3	Time (×1 s) to Wait for ACK
FULLDUP	Off	Full-Duplex Terminal Operation
HBAUD	1200 Bauds	Packet Link (Radio) Baud Rate
HEADERLN	Off	Insert <CR> After Headers
HELP	None	Show Brief Help Text on Screen
HID	Off	Send ID UI Packet Every 9.5 Mins
HOST	Off	Host Mode Active
ID	Immediate Command	Force ID Packet via Unproto Path
IO	Enter Hex Addresses	Read/Write IO Register
LOOK	On	Accept Lower-Case to Terminal
LOCK	On	Morse Receive Speed Lock
MAXFRAME	4	Maximum Un-ACK'D Frames Allowed
MBX	Empty; Enter Callsign	Monitor Channel Without Headers
MOON	0 (Zero)	Monitor While Connected (0-6)
MDIGI	Off	Monitor Digipeated Frames
MEMORY	Enter Hex Addresses	Read/Write Memory Location
MFILTER	$07, $13	Filter Received Characters
MFROM	Empty; Enter Callsigns	Don't Monitor MFROM Callsigns
MHEARD	Immediate Command	Display Callsigns Heard
MONITOR	2	Monitor Mode Level Select (0-6)
MORSE	Immediate Command	Start Morse Mode
MREJ	On	Don't Monitor Calls in MFROM/MTO
MRPT	On	Show Digipeaters in Headers
MSPEED	20	Set Morse Speed in WPM (5-99)
MSTAMP	Off	Time-Stamp Monitored Frames
MTO	Empty; Enter Callsigns	Don't Monitor MTO Callsigns
MYALIAS	Empty; Enter Yours	Alternate MYCALL
MYALTCAL	Empty; Enter Yours	Alternate AMTOR SELCAL
MYCALL	PK-232; Enter Yours	Your Callsign for Packet Address
MYSELCAL	Empty; Enter Yours	Your AMTOR SELCAL
NEWMODE	Off	Return to Command Mode at Disc
NOMODE	Off	Never Switch Modes
NUCR	Off	Nulls to Terminal After <CR>
NULF	Off	Nulls to Terminal After <LF>

Table 5-2.—cont.
Operating Commands for the AEA PK-232 Multimode TNC

Command	Default Setting	Function
NULLS	0 (Zero)	Number of Nulls for NUCR & NULF
OPMODE	Immediate Command	Display Current Operating Mode
PACKET	Immediate Command	Start Packet Mode
PACLEN	128	No. of User-Typed Bytes in Packet
PACTIME	After 10	Packet Transmit Timer (×100 ms)
PARITY	3 (Even)	Terminal Program Parity (0#3)
PASS	$16 <CTRL-V>	Pass Input Editing Character
PASSALL	Off	Ignore CRC in HDLC (Junk Mode)
RBAUD	45 Bauds (60 WPM)	Baudot RTTY Baud Rate
RCVE	Immediate Command	Go to Receive, Morse/RTTY/AMTOR
RECEIVE	$06 <CTRL-F>	Receive-Mode Character in Text
REDISPLA	$12 <CTRL-R>	Redisplay Current Input Buffer
RESET	Immediate Command	Reset BBRAM to Factory Defaults
RESPTIME	10	Minimum Delay Before Sending ACK
RESTART	Immediate Command	Same as Power-On/Off Reset
RETRY	10	Maximum Number of Frame Repeats
RXREV	Off	Reverse Received Data Sense
SELFEC	Empty; Enter SELCAL	Start Selective FEC with SELCAL Packet
SQUELCH	Off	Select Receiver Squelch Polarity
SRXALL	Off	SELFEC Receive Selective or All
START	$11 <CTRL-Q>	Resume Sending Data to Terminal
STOP	$13 <CTRL-S>	Stop Sending Data to Terminal
TCLEAR	Immediate Command	Nonpacket Clear Transmit Buffer
TIME	Immediate Command	Insert "Send Time" in Text
TRACE	Off	Hex Dump of Packet Frame
TRANS	Immediate Command	Start Transparent Data Mode
TRFLOW	Off	Terminal Flow CTRL—Transparent
TRIES	0 (Zero)	Show or Force Retry Count
TXDELAY	30	PTT Key-to-Data Delay (×10 ms)
TXFLOW	Off	PK232 Flow Control—Transparent
TXREV	Off	Reverse Transmitted Data Sense
UNPROTO	CQ	Path/Address to Send UI Frames
USERS	1	No. of Multiconnections Allowed
USOS	On	RTTY "Unshift on Space"
VHF	On	PACKET—Wide or Narrow Shift
WIDSHIFT	Off	RTTY—Wide or Narrow Shift
WORDOUT	Off	RTTY—Word or Character Output
XFLOW	On	Software Flow Control
XMITOK	On	PTT Line Can Be Keyed
XOFF	$13 <CTRL-S>	Stop Sending Data to Terminal
XON	$11 <CTRL-Q>	Resume Sending Data to Terminal

kit (a "new style" AX.25 version 2 unit), the PK-2 (an expansion and combination of the old and new for total compatability), and a PK-1L miniature TNC for portable use. GLB also manufactures a fascinating line of VHF and UHF transmitters, receivers, IDers, helical "front ends," preamps, etc. This company is into packet in a big way! A detailed look at GLB's exciting PK-1L is included in our chapter on portable packet. Meanwhile, let's look at GLB's other items.

The PK-1 (Figure 5-14) supports both Vancouver and AX.25 protocols, and their selection is automatically handled during operation. The unit consists of a well-planned PC board (Figure 5-15) with two edge connectors (one to the computer, one to the transceiver and power supply) mounted in a metal cabinet. Extra chip positions are provided for expanding the internal memory. Although edge connectors are used, RS-232-compatible levels are included (+12 volts and ground which most RS-232 items accept). An optional ±12 volt RS-232 adapter is also available. Speeds between the TNC and computer are selectable from 45 to 9600 baud, and speeds of 300, 600, or 1200 baud are selectable between the TNC and radio. An ASCII-to-Baudot adapter is even available for those interested in using a mechanical teletype with the TNC for packet—a novel idea.

Figure 5-14. The GLB PK-1 compact and easy-to-install TNC.
(Courtesy GLB Electronics, Inc.)

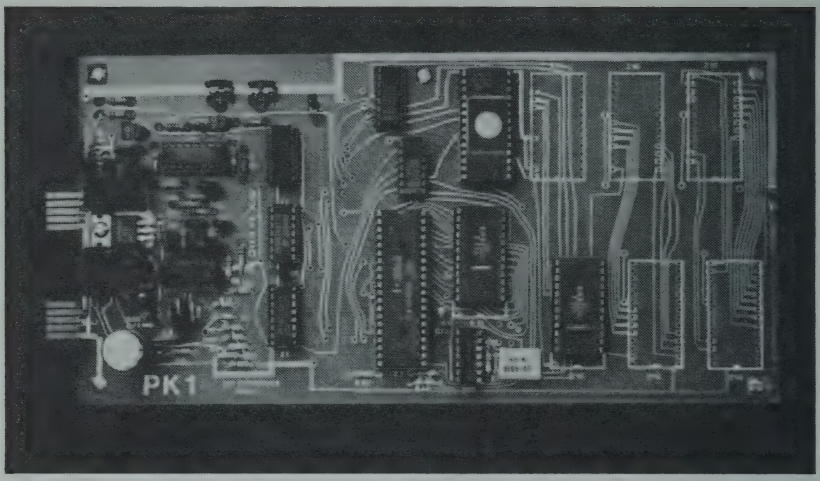


Figure 5-15. Internal PC board used in the GLB PK-1 TNC.
(Courtesy GLB Electronics, Inc.)

The unit includes an exceptionally large set of command parameters (see Table 5-3) which are retained in EPROM, and its manual provides necessary operator support. Getting the unit going consists of merely plugging in its included 12 volt DC wall adapter, connecting to an RS-232-compatible computer (check with GLB if questionable), loading a terminal program into the computer, connecting an amateur transceiver, and selecting baud rates. The stand-alone flexibilities of the PK-1 have earned it a popular position among digipeater builders and operators, because it can be initialized and used with a transceiver at a remote site. This unit doesn't include AX.25 version 2 deluxe capabilities, but it illustrates what can be achieved within a limited budget.

GLB's TNC-2A is an expanded TAPR 2 clone available in kit form. The package comes with two manuals—one detailing assembly and one detailing operation. Both serve their purpose very well. After assembly, the unit looks like that shown in Figure 5-16. The TNC-2A supports 300-, 1200-, 2400-, 4800-, and 9600-baud computer speeds and 300- or 1200-baud radio speeds. Its set of commands is very similar to packet's standard set such as that used with AEA's Pakratt, Kantronic's KPC-2, etc. Packet parameters are stored in 32K of EPROM (approximately ninety-five commands to give experimenters a real challenge) while data can be stored in 16K of lithium battery-backed RAM. GLB also designates this unit as RS-232 compatible,

Table 5-3.
Summary of Operating Commands for GLB PK-1

Command	Function
Input/Output Commands (Misc Categories)	
I(ab)(data)	Enter (ab) bytes of data to send (block mode)
I(data)	Enter all bytes up to Control-D (normal mode)
K	Kill contents of transmit buffer.
T	Type transmitter buffer contents
OA(n)	Receive packets only with address "n" in VADC (255 = all).
OA(call sign)	Receive packets only from station (call sign).
OB(D/E)	Disable/Enable block mode
OC(D/E)	Display info from other calling stations while connected.
OD(D/E)	Disable/Enable noninfo Data display
OF	Output one frame from the queue.
OH(D/E)	Disable/Enable Header display
OI(n)	Set value of "chat" mode timer
OL(D/E)	Disable/Enable auto line feed on carriage return
OM(D/E)	Disable/Enable RTTY motor control mode.
ON(n)	Insert "n" nulls after a carriage return
OO(D/E)	Disable/Enable Connect-Only mode.
OP(n)	Set PID value to "n."
OQ(D/E)	Disable/Enable Queue-up mode
OU(D/E)	Disable/Enable status updates
OW(n)	Limit page width to "n" characters.
DH	Transmit a 2200 hertz (High) tone.
DL	Transmit a 1200 hertz (Low) tone.
DO	Turn off test tone.
Beacon Commands	
BC	Put Beacon Call signs into active use.
BD(call sign)	Enter a Beacon Destination call sign.
BK	Kill beacon message.
BR	Recall a beacon message.
BS	Store a beacon message.
BT	Set Time value for automatic beacon.
BV(call signs)	Enter Beacon repeater call signs (Via).
Set-Up Commands (Category "S")	
S(return)	Display system status
S(n)	Set VADC Address to the number "n"
SB(D/E)	Disable/Enable carrier backoff
SC(call sign)	Set our call sign
SD(call sign)	Set destination call sign
SE(D/E)	Disable/Enable console echo

Table 5-3.—cont.
Summary of Operating Commands for GLB PK-1

Command	Function
Set-Up Commands (Category "S")	
SF(n)	Set length of preamble to "n" bytes
SG(D/E)	Disable/Enable "garbage" mode.
SH	Set highest number of frames per packet to "n."
SI	Reinitialize (Set to power-up values)
SJ(n)	Set link baud rate
SK(n)	Set transparent mode time value to "n" fiftieths of a second.
SL(n)	Set maximum packet length to "n" characters
SM(n)	Allocate "n" 256-byte blocks to transmit buffer (1 to 7)
SN(n)	Set number of tries to "n"
SP(n)	Set receive/transmit delay to "2n" milliseconds
SQ(n)	Set value for T2 (connection timer)
SR(B, D, H OR O)	Set number system to Binary, Decimal, Hex, or Octal
SS(n)	Set CW identifier speed (WPM)
ST(n)	Set retry delay time to "n" tenths of seconds.
SU(D/E)	Convert output to all uppercase characters.
SV(call sign)	Enter repeater call sign.
SX(n)	Set AX.25 protocol.
SY(abcdefghikl)	Set control characters for Insert and Chat modes.
SZ(E/D)	Enable/Disable leading zeros
Manual Operations (Category "M")	
MA(n)	Set address field to value "n"
MC(n)	Set control field to value "n"
MD	Manually disconnect our end
ME(n)	Set transparent mode exit character.
MF(D/E)	Output automatic LFs after CRs to other station in chat mode.
MI	Transmit our call sign in CW.
MK(D/E)	Enable "—Ack—" message in "chat" mode.
ML(D/E)	Enable automatic entry into "chat" or "transparent" modes.
MM	Return number of 256-byte memory blocks available.
MR(D/E)	Enable AX.25 repeater operation.
MS	Enter "Chat" or "Transparent" mode.
MT	Transmit custom packet with info in buffer
MU(D/E)	Set unconnected mode.
MV(D/E)	Enable eavesdropping on repeated packets display them).
MX(D/E)	Enable transparent mode.
Automatic Operating Commands (Category "A")	
AA	Send info acknowledge (after an "AW").
AC	Initiate a connect request to another station

Table 5-3.—cont.
Summary of Operating Commands for GLB PK-1

Command	Function
Automatic Operating Commands (Category "A")	
AD	Send a disconnect request
AH	Halt. Stop repeating an unacknowledged packet.
AI	AX.25 send unnumbered info packet, VADC send info packet.
AR	Resume sending (after a halt).
AS(D/E)	Standby mode (no receive/xmit).
AT	Transmit current packet until acknowledged.
AW	Send a "Wait" acknowledge (RNR) to stop other station.
AX	Abort current transmission

with its DIN-25 pin exchanging serial data in the traditional manner discussed in Chapter 3. That is, Pins 2 and 3 carry data to and from the computer, and Pin 7 is ground. The input port recognizes +3 volts or higher as binary 0 and +1 volt or lower as binary 1. Check with GLB concerning additional compatibility questions. Finally, a wall adapter rated at 12-volts DC and 200 mA is included with this popular TNC.

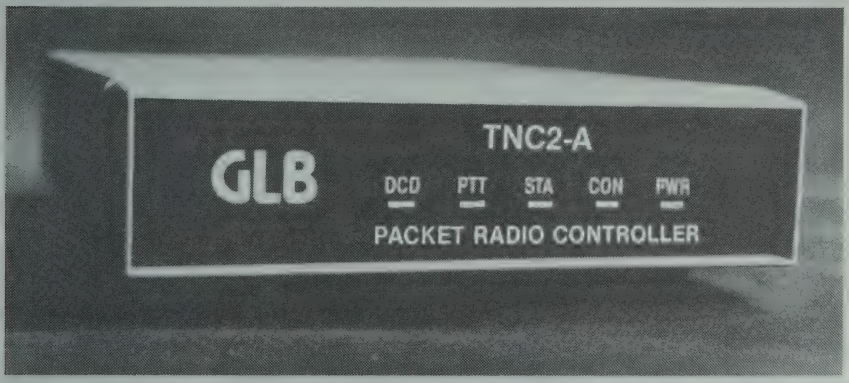


Figure 5-16. The GLB TNC-2A professional kit.
(Courtesy GLB Electronics, Inc.)

During this book's preparation, GLB announced their new PK-2 TNC, a unit supporting AX.25 version 1 and version 2 plus V-1 protocols. The unit will support multiconnects and protocols, and those connects can be mixed. This capability probably reflects market directions around GLB's home base, which is close to the Canadian border. Unlike prior GLB units,

the PK-2 provides automatic computer or terminal speed syncing between 45 and 19,200 baud. Assuming the speeds are fast enough, it also allows the TNC to "talk with" the computer and radio simultaneously. Universal TNCs, and those with slower speeds, are often limited in this respect. The PK-2 also supports true RS-232 data levels rather than compatible levels. An interesting feature of the PK-2 involves its select or reject BUDLIST parameter which can be implemented for both operating and digipeating. For more information, contact GLB Electronics, Inc., 151 Commerce Parkway, Buffalo, NY 14224.

Kantronics

Assembling their own form of TNC-2/AX.25 version 2-compatible units, Kantronics offers their popular KPC-2 Packet Communicator (see Figure 5-17). This attractive and versatile TNC is designed for easy setup and use with almost any home computer. The KPC-2's manual includes a variety of short, basic terminal programs for many computers such as Radio Shack, ATARI, and Commodore 20/64 (which can be interfaced with the KPC-2 via its TTL level settings). Since this unit includes those supporting items and a wall adapter DC supply, we consider it a "packet package." The KPC-2's command set is similar to AEA's, and it's easy to use. Serial RS-232 data interfacing also uses the traditional DIN-25 Pin 2, 3, and 7 hookups. It's a nice unit for both old and new packeteers.

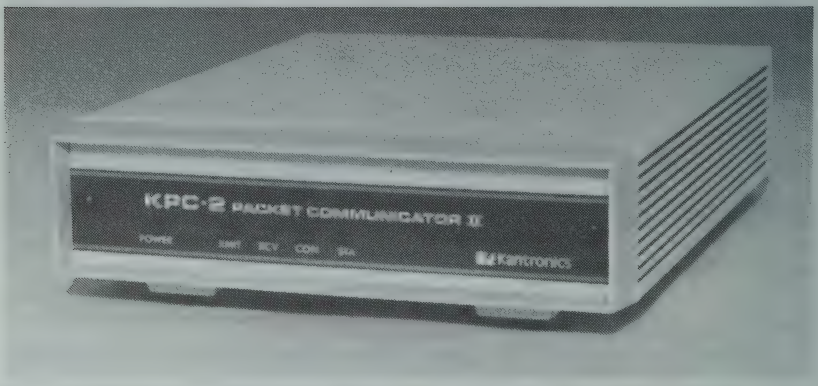


Figure 5-17. Kantronics' popular KPC-2 Packet Communicator.
(Courtesy Kantronics, Inc.)

Moving forward in an interesting direction, Kantronics recently introduced their KPC-2400—a KPC-2-type unit that also includes 2400-baud output with standard 1000 Hz shift (see Figure 5-18). Kantronics believes that 2400 baud can and will replace 1200 baud as the commonly used speed for VHF packeting. Their reasoning is that, as packet radio channels become busier and more congested, faster baud rates will allow that data to move in a more efficient manner. In addition, there is the fact that bandwidths of VHF transceivers are fully capable of running 2400 baud. Not forgetting their KPC-2 customers, Kantronics offers retrofit 2400-baud upgrade kits or trade-in allowances for KPC-2400s. It will be interesting to watch this new 2400-baud unit as time passes. Understand, we're discussing 2400 baud on the local level, not at the "trunking" or high-speed level. For more information on the previous items, contact Kantronics, Inc., 1202 E. 23rd Street, Lawrence, KS 66046.

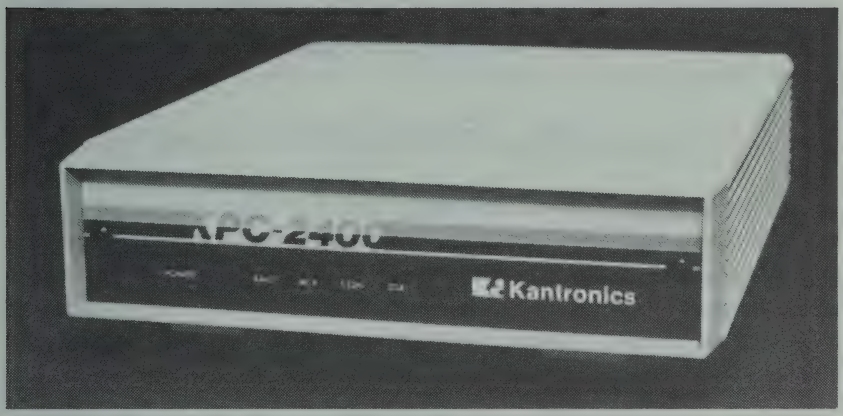


Figure 5-18. The Kantronics KPC-2400 1200/2400 baud TNC.
(Courtesy Kantronics, Inc.)

MFJ

In the summer of 1986, MFJ's TAPR2/TNC-2 clone units (Figure 5-19) finally began appearing on dealer shelves. The economically priced MFJ items sold to enthusiastic buyers like wildfire. The unit was apparently worth its wait, and MFJ now is quite busy turning them out fast enough to supply the multitudes. MFJ's 1270 is almost a perfect clone except that its board is slightly wider to accommodate both RS-232 and TTL interfacing capability. The unit will thus mate with nearly any home computer. One can simply

set the 1270's DIP switches for the desired baud rates and levels, connect radio and computer (a 12 volt, 200 mA power source is included), load a terminal program into the computer and begin packeting. The unit includes 16K of EPROM and 16K of battery-backed RAM (expandable to 32K), plus counter and software for modem self-calibration. It will operate with terminals up to 9600 baud, and speeds up to 56,000 baud are possible with an easily connected external modem. These features, along with the 1270's reasonable price, make it attractive for home or remote digipeater use. After initialization, both the 1270 and a VHF transceiver could be battery powered.

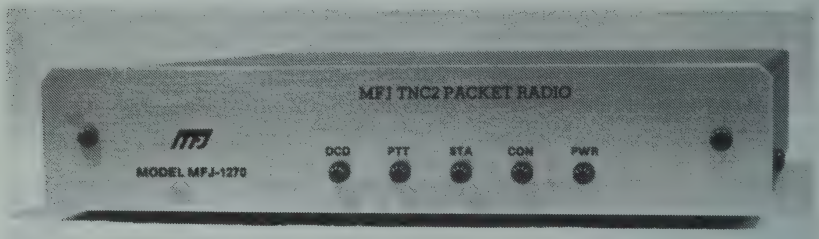


Figure 5-19. The MFJ 1270 TAPR TNC-2 clone.

MFJ's very impressive unit, along with a manual that is an almost identical clone of a TAPR 2 manual, reflects an ingenious approach to packet radio. MFJ supports the 1270 further with an optional quick-start package that contains proper interface cables and terminal software on cassette or disk. The setup's inner beauty is its flexibility to shift and expand with future developments in the packet radio world. For more information, conect MFJ Enterprises, Inc., P. O. Box 494, Mississippi State, MS 39762.

Newsome

If you would like to "test the water" before jumping into the packet action, Newsome offers an inexpensive receive-only modem kit for use with Commodore 64/128 computers. As shown in Figure 5-20, the package consists of all necessary parts and connectors, predrilled PC board and plug-in-software. The unit assembles in less than an hour. The owner can then monitor any and all 1200-baud activity in the area. It's a clever idea which holds merit for vacillating packet investigators. For more information, contact Newsome Electronics, 19675 Allen Road, Trenton, MI 48183.

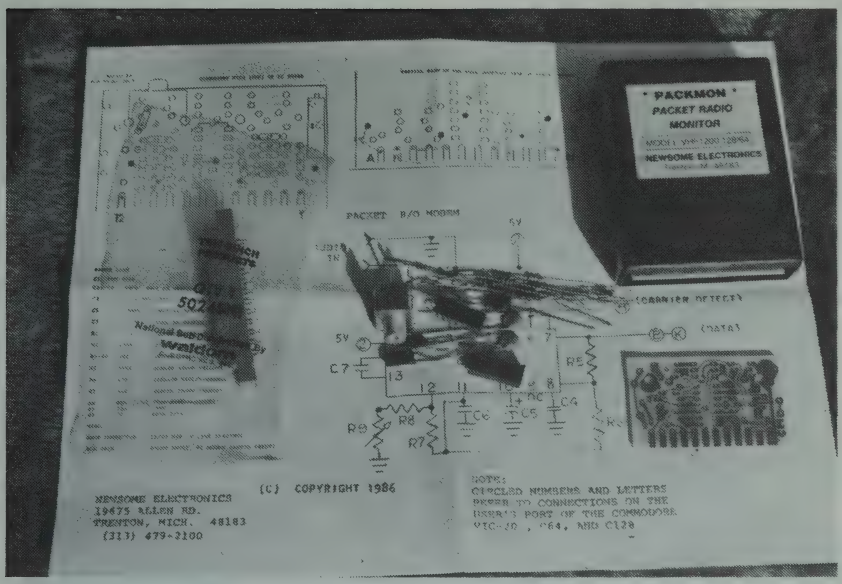


Figure 5-20. Newsome Electronic's easy-to-assemble receive-only kit.

Tono

Tono's EXL-5000E is a multimode communications terminal designed for stand-alone operation of RTTY, ASCII, AMTOR, and Morse. The unit recently has been expanded by the manufacturer to also include packet radio capabilities, providing operation of all printed modes in a well-designed and compact package that blends with any amateur setup. The basic Tono terminal consists of the electronic and display section which connects to its mating keyboard via a multiconductor cable (see Figure 5-21). The unit's importer, Amateur Wholesale Electronics, provides prewired cables for connecting the EXL-5000E directly to an MFJ or Kantronics TNC. The end result is a deluxe console system that's a true pleasure to operate. The system includes a five-inch monitor with auxiliary video connections for a second monitor, an audio monitor, type-ahead buffer, several memories for canned messages, built-in AFSK modulators, and a large (upper area) multisegment LED tuning indicator. Battery backup is provided for the memories, and the Tono terminal can be powered from AC or 12-volt DC sources—nice for Field Day-type activities. The unit operates all popular RTTY speeds, AMTOR ARQ, and FEC, plus CW at 5 to 100 words per minute.

Figure 5-21. The deluxe multimode TONO EXL-5000E terminal.
(Courtesy Amateur Wholesale Electronics)

The Tono terminal's packet radio capabilities and operations are essentially determined by its interconnected TNC. The terminal mainly "does its own thing" and acts like a data communication terminal for the TNC. That TNC's protocol capabilities, memory, speeds, modem, instruction manual, etc., influence overall packet radio performance. Future upgrades using the Tono concept seem simple enough—merely cable in a new TNC, study its manual, and join the action. For more information on the Tono terminal and TNC interfacing packages, contact its exclusive North American distributor, Amateur Wholesale Electronics, 8817 S.W. 129th Terrace, Miami, FL 33176.

HAPN

The Hamilton Area Packet Network of Canada has designed a quite impressive packet radio system for use with the IBM PC and its many compatibles. The HAPN package consists of a plug-in packet adapter card and supporting software. The PC card, shown in Figure 5-22, is complete within itself, providing all necessary TNC-related software and hardware, 1200-baud modem, external modem connections for speeds up to 9600 baud, etc. One only needs to connect an FM transceiver to the HAPN board's socket, and the system is ready for deluxe packet action. AX.25 software is included with the HAPN package; optional software for V1 and V2 protocols is also available. This system seems like a perfect way to get going in packet in top style. Considering HAPN's devotion to packet developments, we suspect any future packet innovations will be integrated and readily available to HAPN customers. For additional details, contact the Hamilton Area Packet Network, Box 4466, Station D, Hamilton, Ont., Canada L8V4S7.

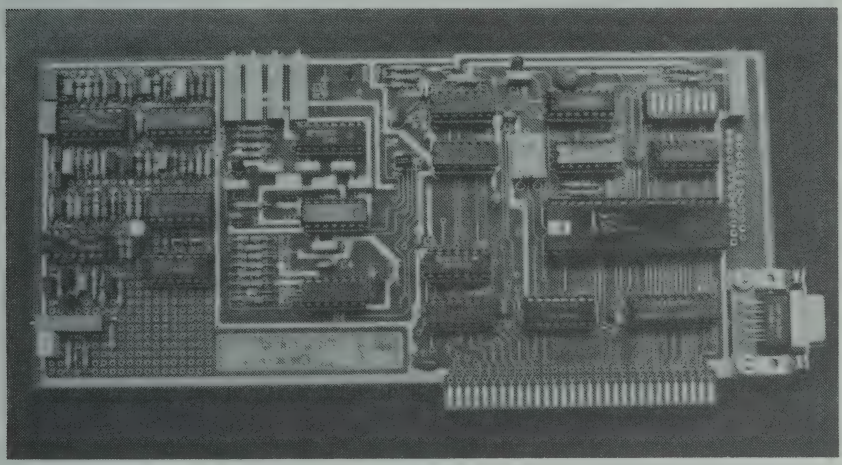


Figure 5-22. The HAPN packet radio adapter card for IBM PC-compatible computers.
(Courtesy Hamilton Area Packet Network)

VADCG

The Vancouver Amateur Digital Communications Group, led by the original amateur who started the packet revolution, Doug Lockhart, VE7APU, presently provides kit versions of their TNC+. The kit is well-documented, and provides one with a good working knowledge of TNCs and their circuitry

through construction. Naturally, the unit is impressive in both design and expansion capabilities. The TNC+ supports 64K of memory and operates at standard or nonstandard computer speeds from 45 to 39,000 baud. The TNC+ radio's side is especially flexible to support a wide variety of speeds for present and future times—300 to 64,000 baud. The TNC+ is also designed to interface with any imaginable kind of external modem. The unit supports AX.25 protocol, with optional capabilities of including V2 or V3 protocols. For more information on this pioneering packeteer's dream unit, contact The Vancouver Amateur Digital Communications Group, 9531 Odlin Road, Richmond, BC, Canada, V6X1E1.

Summary

This chapter's overview of packet radio equipment included a cross section of various units to give you a working knowledge of the packet market, pointing out different manufacturers' variations. The information also lays the groundwork for understanding pieces of hardware that will be developed in the future. We couldn't possibly include all equipment, and our apologies to excluded manufacturers. As we've pointed out several times, the packet radio world is expanding like wildfire, and new products are being announced each month.

Many characteristics and features of the commercial packet equipment surveyed in this chapter were explained in greater detail in previous chapters. If you feel you need clarification, please review Chapters 2, 3, and 4.

The unit today that is the prototype for many licensed clones is TAPR's original TNC-2—the one developed by TAPR while TNC-1s were being integrated into amateur setups nationwide. Model number similarities between TAPR's original TNC-2 and GLB's TNC-2A are coincidental. Today, TAPR continues work in the research and development areas of packet radio. Tomorrow's packet gear could easily be the result of their efforts. Meanwhile, there's plenty of equipment readily available.

Setting Up the Packet Station

As most radio amateurs will surely agree, a well-planned and cleverly assembled setup offers the maximum enjoyment to its proud owner. High scoring contesters and serious DXers are especially aware of that fact because they're often involved in long operating stints and depend heavily on their operating atmosphere being both pleasant and motivating. Factors that can help include everything from personally comfortable layouts with rewarding views and award-covered walls to perfectly placed microphones, keys, and other accessories. Since each of us continually strives to better our own setups in these respects, we're always looking at and studying photos of others' stations in monthly amateur magazines. And why not? It's a great way to spot another idea worth trying in our own station. When every possible advantage and asset is at our fingertips and useful guides or charts are under our desk's glass top, there's an irrepressible feeling of confidence and professionalism. Many of these ideas also apply to packet radio setups; however, several additional points many amateurs may not initially consider are also noteworthy. We've probably heard of these ideas, but we never really wholeheartedly think about employing them until someone else emphasizes their importance or benefits. The purpose and intent of this chapter, then, is to give you a working overview of good and bad locations for packet radio setups, and to explain some details regarding power and wiring, static/spike protection, ventilation, cleanliness, etc. We'll look at equipment layout and protection from several viewpoints; we'll study interference to packet setups from outside influences, investigate monitor screen radiation, and outline several operation aids. The knowledge gained can then be used to create your own perfect setup that's a sheer joy to operate—until another new and better idea hits and the urge for improvement strikes again. Change is indeed the only constant in this game, but that's just part of the fun.

One of the first considerations for a fixed or semipermanent packet setup is determining a good "computer-friendly" arrangement. These thoughts may or may not coincide with one's existing amateur radio setup for several reasons. Many of us tend to assemble our main stations, for example, in what might be considered as "computer-harsh" atmospheres. This includes everything from damp garages or basements to fixed-up rooms with thick static-prone carpeting. Our transceivers aren't overly sensitive to these pitfalls, since they're designed to operate near high-power amplifiers (and those warm amplifiers tend to deter dampness in nearby gear). Computers, on the other hand, can be quite sensitive to stray RF, and static charges from a scrubbed carpet can play havoc with their inner circuits. Likewise, main setups are often established in an area that simply can't support more equipment—we would need to discard something to make room for additional gear. For uninterrupted enjoyment, the main setup may be located in a quiet area away from most of the activity, but one might prefer locating a pocket setup in a room or area that's closer to the rest of the family. If you're planning to enjoy packet radio to its fullest, remember to include your family in the plans along with the convenience and comfort of the setup.

After evaluating one's needs and keeping in mind additional roles of the packet setup's computer, a dual purpose concept may become attractive. In other words, if it's accessible and mutually agreeable, the packet computer may serve double duty as a family bookkeeper or data base during off-the-air times. Otherwise, a second computer might prove to be the perfect answer to family harmony. Hunting for a setup's computer and hooking it up before each operation gets old fast. The second computer idea also holds merit for amateurs interested in portable setups. There's no reason why packet or any other version of amateur radio can't go with you on out-of-town jaunts. In fact, it's just one more great way to enjoy the fascinating world of personal communications.

Planning and Laying Out

As previously mentioned, initial plans for the packet radio setup's location will be influenced by family relations and the computer's possible secondary applications. If the computer will also be used for word processing or as a data base, the home office or den may prove attractive. If the computer is intended primarily for amateur use, and if it's a physically large system, secondary applications may require that other family members do their

computing in the radio room. These are situations when that idea about a second computer begins to sound more reasonable. Again, thinking flexibility has its benefits. Few amateurs settle on their first plan as a permanent setup. We change, if for no other reason, to keep things interesting. Fortunately, amateur radio setups are adaptable to our changes without many problems.

While considering the location for your packet setup, pay close attention to details involving both present and future operations. AC outlets, access to relatively close antenna locations, and availability of a nearby telephone connection for modem use must be considered. The location should also be reasonably clean and free from moisture, and should have adequate ventilation. Heat and dirt are the two main enemies of electronic equipment.

The use of "clean," or dedicated, AC outlets for a computer system provides both smooth and reliable operation without unexpected data dumps, and it protects the computer system from harmful voltage spikes or transients. The best bet here is placing the computer system on a separately run AC line, or at least on its own set of outlets not used by other equipment. An efficient surge suppressor connected to that outlet is extremely advisable, not only for distant or local lightning protection, but also to minimize spikes from home appliances such as vacuums, blenders, etc. Motors of all types are prone to creating inductive kicks—spikes that are fast enough to go straight through fuses or circuit breakers. The shorter the time period of a spike, the higher its amplitude, and damaging capabilities. If you're taking the chance of operating an expensive computer without surge protection (and it is risky), at least unplug the system from its AC outlet when it's not in use. One solution here involves the use of a switched, fused, transient-protected multiple AC outlet box or strip. These items may be slightly expensive, but they are good insurance and they provide a convenient "master switch" setup. If possible, select the type that disconnects both sides or wires of the AC line via its master switch.

If you're setting up a separate VHF station for packet, access to a nearby antenna location and transmission line routing is another important consideration. Running 100 feet of small coax for 2-meter use creates the same loss as running 1000 feet of cable at twenty meters. If you can't get the antenna close to the rig, consider relocating the rig closer to the antenna.

An increasing number of amateur radio services, bulletin board systems, and commercial firms are also making their products and services available via telephone. After you've joined packet activities and learned more about these modem-accessible services, you'll probably want to try them yourself. With that in mind, you may want to include or add a telephone jack or a

private line for modem use. Conventional telephone lines are usually quite adequate for 300-baud use, but their inherent noise can reduce communications reliability at 1200 baud and faster speeds.

Although dust and heat are a natural part of our day-to-day lives, there are measures you can take to help your computer system survive the elements. The first logical consideration is to locate the computer in a clean environment. Likewise, avoid allowing foreign particles to accumulate on or near the computer (this includes drinks and snacks). Since many of us spend several hours of each day away from home or sleeping, our computers have plenty of time to collect harmful dust and dirt when they're not being used. Several manufacturers produce dust covers for computer systems of all types, and they're well worth the investment. You probably are using dust covers for your main amateur radio setup already. Two dust cover examples are shown in Figures 6-1 and 6-2.

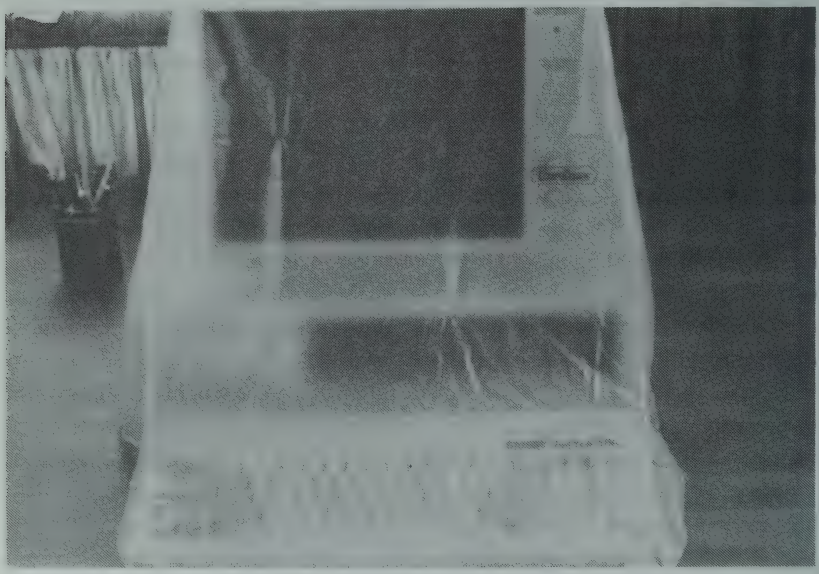


Figure 6-1. Inexpensive dust covers for the home computer system.

Avoid locating your computer and/or software in direct sunlight or near heat sources. This is especially important in the case of a floppy disk. Ideally, computers should be located in cool places to control overheating. If you're confined to a restricted area, add extra feet to the computer and related items, then use whisper or muffin fans to move air across the units. These small

yet efficient fans are usually quite plentiful at hamfest flea markets, and they're inexpensive. You can simply set them upright at the back of a desk and hold them in place with double-sided tape.

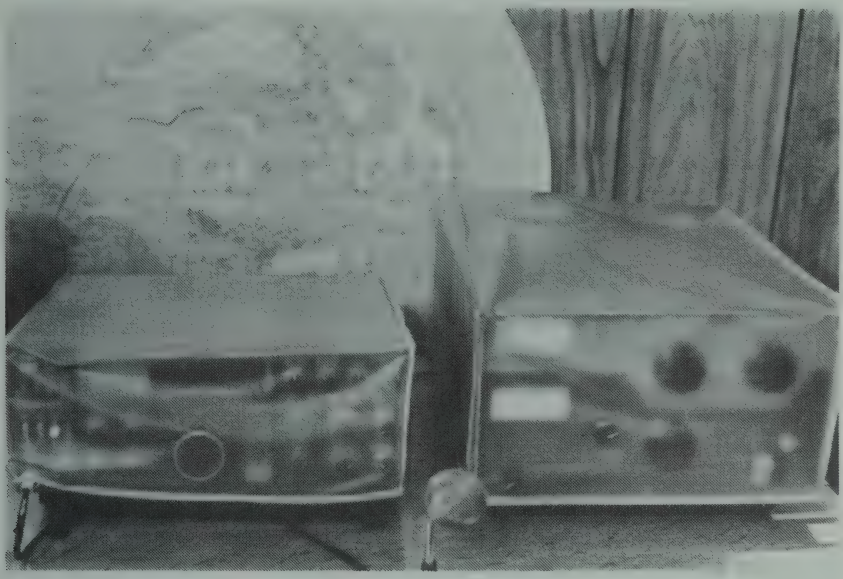


Figure 6-2. Dust covers for amateur radio equipment.

Is the floor beneath your packet radio or computer system covered with a nice thick carpet or rug? Have you noticed how walking along such carpeting and then touching another person or a metal object produces a hefty static electricity shock? Need we remind you of what those static shocks can do to computer systems and software? A few years ago, I engineered in an AM/FM broadcast station with thick carpeting on its floor. During cool weather, I could walk through the carpeted room, out the door (pushing its glass and missing its metal handle), ride the elevator to the building's lobby, buy a snack, and almost knock down the cashier when I handed her a coin. Office supply companies sell a wide variety of anti-static mats designed to lay over carpeting in the area of a computer, and they're well worth the investment. An additional personal grounding post not connected to the computer is another worthwhile idea. Remember to use it faithfully.

Summarizing the previous notes, one should strive to lay out their packet radio setup in a well-ventilated and dry place away from direct sunlight or stray magnetic/static fields. Use dust covers when the setup is not in use,

and antistatic mats over carpeting. A static drain-off terminal at the setup (but not on the computer!) is great for preventing the transfer of personal static charges to computers. Simply remember to touch it before using the system (a small sign over the keyboard may help). We don't mean for these suggestions to sound nit picking; we just want you to enjoy a long trouble-free life from your packet radio and home computer investment.

Precise equipment layouts are basically a matter of personal preference; however, a few tried and proven ideas bear highlighting. We've found that positioning the amateur transceiver and power supply on either side of the computer is preferable to above the monitor or computer. Two main reasons are: heat rises and positioning on the side minimizes stray RF fields. This layout also lets the transceiver's dials, meters and LEDs catch your eye during operation. Which side you select depends on which side your transmission line enters the setup. Try to avoid crossed RF and computer lines behind the setup. A list of operating commands on the wall or under the desk's glass, and a folder of all equipment manuals should finish the layout.

Power Distribution Notes

Since many amateurs have installed or supervised the installation of separate 110/220-volt AC lines for linear amplifiers, the use of dedicated lines for computers is familiar to them. A suitable outlet is installed at the needed place, then cable (such as Romex, which is rated for a specific current and protected from the weather) is run from that point to the main power box (see Figure 6-3). *After disconnecting the main breaker* (and double-checking all wires very carefully with a volt-ohmmeter), the dedicated line is connected via its own breaker to the main box's output. The installed line is then rechecked for continuity, ground, and shorts, and the main breaker is reconnected. NOTE: *Do Not* attempt this installation if you have any doubts, if you're unfamiliar with AC wiring, or if you're working alone without someone knowing what you're doing. AC power can kill you. A slip of even the most knowledgeable hand can cross hot lines. Never take chances with AC lines or power lines that might fall across power lines. Additionally, many states have laws which state that any and all home AC wiring must be done by a licensed electrician. Check before proceeding. The specific size of wire used for dedicated AC lines will depend on its current-carrying ability. Wires too small can overheat and create fire hazards; wires too large are more expensive. Personally, I'll opt for oversized wire anytime. It gives an added

margin of safety (especially several years later), and it provides for future system growth. Number 14 wire can handle up to 10 amps, number 10 wire is suggested for 15 or 16 amps, and number 6 wire is our choice for 20- to 25-amp service. Weather protective coatings have recently become a complete study in themselves. The type suitable for seven years' direct burial is reasonably priced and quite serviceable.

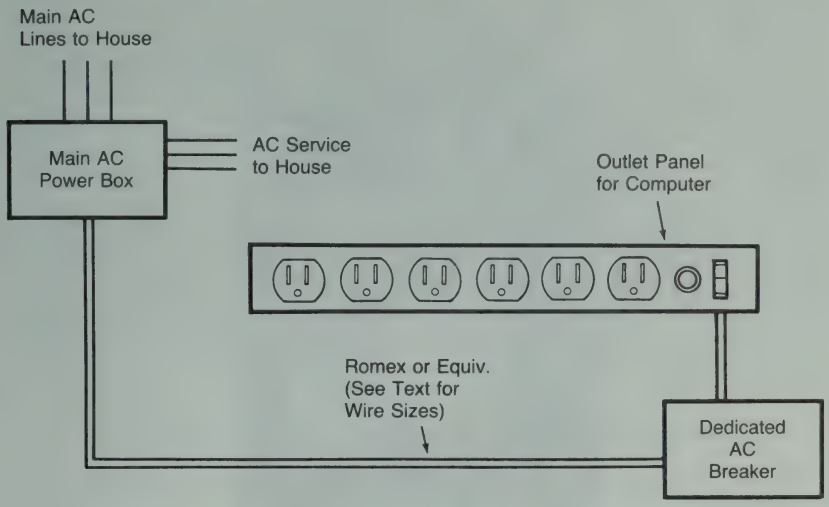


Figure 6-3. Basic layout of a dedicated AC line.

Considering the time-consuming problems of installing true dedicated AC lines, many amateurs seek easier solutions using a home's existing wiring. Depending on whether the house uses radial, loop, or a combination of radial and loop wiring, trying to figure out that wiring scheme can prove to be somewhat confusing. Many amateurs thus adopt the quick and easy way of switching on various AC appliances, systematically turning off various breakers and seeing which ones are connected to which breakers. The computer system is then connected to the safest or lowest risk line (such as that used for one or two rooms' lights and a couple of seldom used outlets), while the setup's transceiver is connected with an extension cord to an outlet on a separate breaker. This procedure usually is sufficient for "barefoot" VHF transceiver setups (below 200 watts), but we don't advise following it for 1500-watt linear amplifier HF setups. The computer system's spike and surge and transient protection device or devices should be installed between its selected outlet and its power plug or plugs. These protectors are readily available at most stores that sell electronic parts and computers (see Figure 6-4).

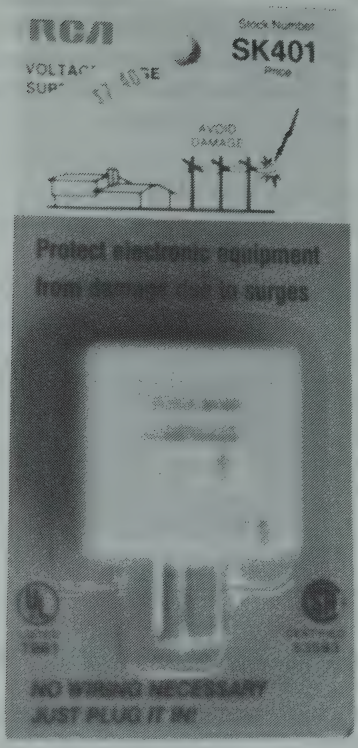


Figure 6-4. AC power transient/spike protectors.

Another very useful device for protecting the station's transceiver against atmospheric charges such as lightning-induced voltage is a surge shunt of Figure 6-5. These inexpensive devices install in coax cable lines between the antenna and transceiver, and drain any harmful charges to ground, thus protecting the equipment from any major hits. Surge shunts are manufactured by Alpha Delta, Drake, etc., and they're readily available nationwide from toll-free dealers of amateur gear. Check any recent issue of *CQ*, *QST*, *73*, *Ham Radio*, or *Worldradio* magazines for advertisements and addresses. If your equipment has a FET, MOSFET, and/or GaAsFET front ends, the advantage of electrical surge protection is simply good reasoning. Lightning and atmospheric discharges do not need to be seen to be damaging.

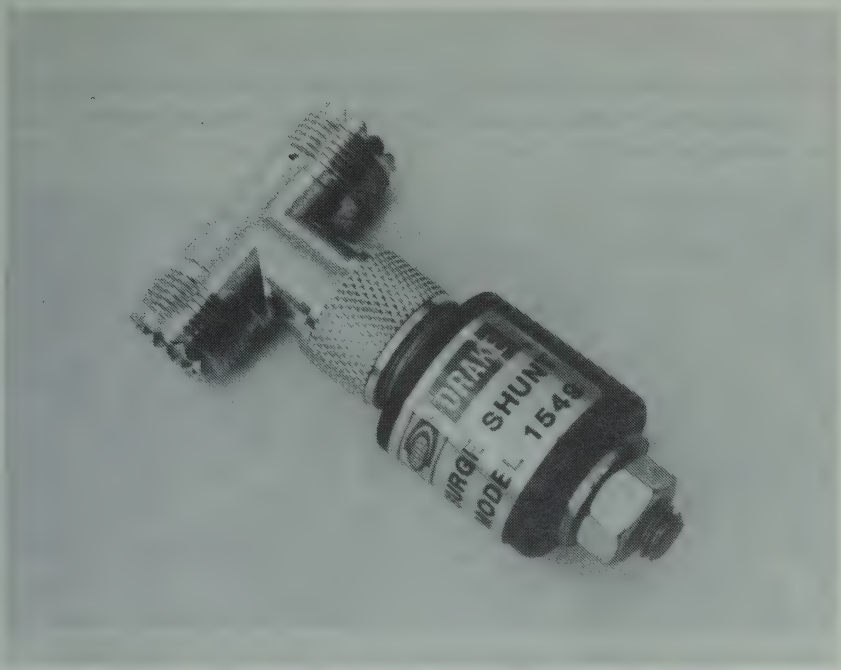


Figure 6-5. A surge shunt to provide vital RF/front end protection for amateur transceivers.

RFI Causes and Cures

One of the more perplexing and potentially irritating shadows lurking near any amateur setup is the possibility of RF interference. This problem doesn't simply involve amateur transmitters interfering with unrelated electronic equipment, but also includes other equipment interfering with amateur transceivers. The best way to understand the situation is to consider HF and VHF/UHF individually.

Thanks to modern station designs and efficient filtering techniques, HF TVI isn't the problem it used to be. Low-pass RF filters for linear amplifiers are available commercially at reasonable prices, and high-pass filters usually can be obtained from a television manufacturer free of cost upon owner request. With that part of the RF problem covered, we only need to ensure that AC power lines from a transceiver do not allow RF to "float back" into common power lines. Avoiding that simply involves bypassing both sides of the AC line to our station's earth ground at the equipment and occasionally wrapping a few turns of the unit's AC cord through a 2½- or 3-inch toroid

core choke as shown in Figure 6-6. Use one core on the transceiver's AC cord and another on the computer. Use tape to secure the wire and position the core near the unit.

Figure 6-6. Wrapping an AC cord around a large toroid core choke to prevent RF leakage.

Television interference at VHF and UHF frequencies is a rare problem, especially at the low power levels used for most packet radio activities. Should such interference evolve, simple reorientation of the VHF/UHF antenna and installation of a toroidal core usually solves the problem quite effectively. Unfortunately, solving the problem of outside interference with VHF amateur setups isn't always a cinch.

Two of today's most common sources of VHF interference are arcing power lines and leaky cable TV systems. Both suffer from being exposed to the weather, and both extend over a wide area. Complaining to one's local facilities or (even worse) complaining to the FCC before investigating is usually a waste of time. If we "get our own house in order" and then conduct an educated study, however, our odds of success approach a hundred percent.

Power line noise sources can be very difficult to locate, but our portable gear and directional antennas are great tracking aids. Since we also live with the noise, we have an ideal opportunity to study its action during weather variations. When looking for line noise sources, use the front, back, and nulling end effects of your antenna to determine the general direction of the noise. Always stick with the main band you're using during these investigations. After you've determined a specific direction, walk the area with a

similar band/mode receiver, and note the spots with the highest noise (use your S-meter for reference). After spotting a suspected pole, house, or whatever, walk several blocks in each direction to confirm your suspicion. Wait a few days and note the nature of the line noise. Constant arcing during light rain can indicate a cracked insulator or small animal trapped across lines. If you observe arcing during windy and/or cold weather (below 40°F but stopping above 70°F), it's usually an indication of corroded or loose line clamps. Recheck your suspected location of the noise source. Do your readings still confirm a precise location? Do you have all the facts in order to describe them exactly to a power company official? If so, you're ready to call. Try to reach the company's communications department rather than a complaint officer or engineer. They will sympathize with your problem (you may even be talking with a fellow radio amateur), and can help secure the fastest possible repair. In fact, the company's communications department may indeed be the "line noise department." Explain your problem with the results of your investigation, maintain a good attitude, and you'll be on the most direct path to a solution.

Leaky cable TV systems and their consequent radiation within amateur bands is a problem that's growing nationwide. Indeed, the affected amateur and his or her neighbors are faced with the decision of either reporting the leakage or adding a TV RF amplifier and tuning in the free service being made available. However, because a substantial amount of cable TV leakage falls right in the middle of 2-meter allocations, and since we're true packet devotees, the decision isn't difficult. The same basic investigation guidelines discussed earlier for localizing power line noise sources also hold true for leaky TV cables. The main problem is convincing the cable company to repair its leak. Sometimes the fear of giving away their service is sufficient motivation, but sometimes it isn't. Sometimes the ARRL and/or FCC are helpful, but legal proceedings move slowly. As an alternative, our advice to enthusiastic packeteers would be to consider switching to a beam antenna and using a front-to-back ratio to minimize interference, try a remote base/receiver, or digipeat through a nearby packeteer. You'll probably find that solving the problem using those measures required less than half the time it would take otherwise. In addition, the level of moisture will probably change the levels of cable leakage anyway (depending on the type of problem). TV cables are usually the lowest lines installed on power poles (beneath telephone lines). They are also assembled with simple (that is, cheap) T connectors, and very few cable companies weatherproof the connections. After one or two years, the connectors corrode or literally fall apart.

The resulting radiation then occurs along cables and between line amplifiers. Since those amplifiers are usually situated every few city blocks, initially locating the radiation center isn't difficult. The more accurately you pinpoint the leak's source before contacting a cable company manager, the greater your chance of rapid repairs. Once again, we emphasize the importance of maintaining a respectful and professional attitude. You represent amateur radio and its proud heritage. First impressions are often permanent impressions.

Home computer systems themselves can occasionally be a nasty source of RFI, especially when the packet station's antenna is near the computer. Poorly installed antenna connectors at the rear of a transceiver also allow computer RFI to leak into the receiver. This problem can be checked by disconnecting the setup's antenna, clipping a short lead to the transceiver or receiver's antenna connection, and tapping a few keyboard strokes while listening to the receiver. Computer RFI will be unmistakable. Corrective measures include cleaning up or reinstalling new coax connectors on transmission lines and moving the setup's antenna to minimize picking up computer RFI. Naturally, well-shielded coax should be used with VHF/UHF systems, and indoor antennas near computers should be avoided.

Recently, several studies have been conducted regarding X-ray and related radiations from monitor screens. The problem was brought to light by professional computer operators experiencing eye problems during long-term exposures. Although the facts are unknown or unrevealed at this time, there are some noteworthy points worth considering. Video monitors and televisions using potentials above 27 kV on their cathode ray tubes or picture tubes may emit soft X rays that *might* be measurable within six to twelve inches of the tube's screen. Beyond that distance, radiation is essentially unmeasurable. The unit's internal high-voltage rectifier may also emit soft X rays through a unit's plastic case, but again their ability to create harmful effects is minuscule. Indeed, over ninety percent of a picture tube's X rays are stopped by its front glass. Viewing printed material on a monitor screen over a long time frame, however, can create noticeable eye strain. In addition to focusing on a specific area for several hours, a monitor screen is also a light source. This combination may cause fatigue and muscle strain, especially if the screen's brightness, glare, and color settings are irritating. Notice the points we mentioned involve long-term use, not a few minutes behind a packet system's monitor each night. Our suggestion for minimizing eye strain is to select a monitor color that's restful to your eyes, use a glare-proof screen cover, and maintain the monitor's brightness at a comfortably low level.

Station Convenience Aids

Although a packet radio setup is relatively easy to run in its basic form, a few additional operating aids can turn using the system into a really enjoyable experience. Some of the more obvious convenience aids would include keyboard overlays, monitor glare filters, transceiver coaxial switches, and a comfortable chair or desk. Items in the occasionally overlooked category include protective storage cases for important disks, a cassette tape recorder with a group of cassette tapes, and possibly an attention-grabbing connect alarm.

An enclosed floppy disk case similar to that illustrated in Figure 6-7 is a good way to protect vital software. Cases of this type are usually supplied with their own lock and key plus several vertical separators. They are good protection against dust and inquisitive young hands, and they help the operator avoid confusion that often leads to damaged disks. Floppy disk cases are available from most office supply or computer supply firms, and prices often vary significantly. Shopping for bargains in magazines and at hamfests or computerfests often has its rewards too.

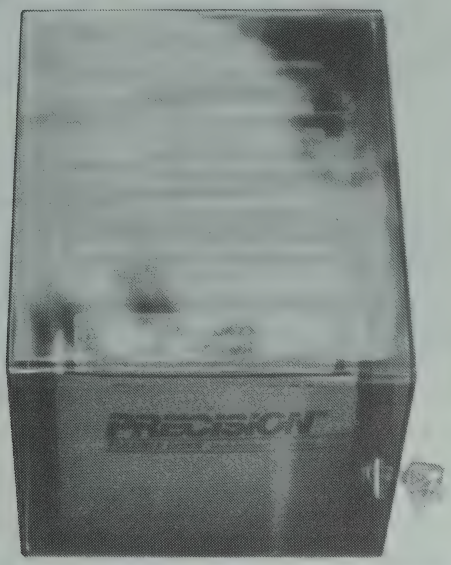


Figure 6-7. A locking storage case for floppy disks.

Since packet radio's off-the-air signals are pure audio tones, a cassette tape recorder with good speed regulation and several high-quality tapes can successfully record these signals. Although one must be CONNected with another station to conduct a two-way conversation or QSO, prerecorded packet messages can be reviewed with a TNC and computer using its DISConnect mode. Some attractive benefits of this prerecorded packet action capability include checking a new TNC or computer setup, demonstrating packet upon a moment's notice, or easily investigating packet activity during out-of-town travels. Assuming one carries a small cassette recorder and 2-meter handheld talkie on short trips, the new area's packet activities can be recorded and reviewed after returning home. Likewise, special QSOs and full data files received and recorded on floppy disk can be recorded on cassette as a back-up. The main consideration in selecting a suitable recorder is ensuring good speed regulation. An example of tape recorder convenience is illustrated in Figure 6-8.

Figure 6-8. A cassette tape recorder for storing off-the-air packet messages.

Several enterprising individuals have recently begun marketing connect alarms for use with various TNCs, and their use is proving to be quite beneficial. Assuming you're out of monitor view or not paying attention when another station connects with your setup, the alarm produces an unmistakable "beep, beep, beep" announcing the event. Using such an alarm is a great

way to add excitement to a station, especially during visitor displays. The market for connect alarms and other packet convenience aids is changing and expanding rapidly. We suggest checking the advertising sections of recent radio publications such as *CQ*, *QST*, *73*, *Ham Radio*, *Worldradio*, and *Computer Trader* for details of recently introduced items.

Improvements Are Continuous

After initial assembly and operation of a packet setup, there's a natural tendency to start thinking about improvements that would expand the station. Indeed, many amateurs find those pursuits as or even more enjoyable than actually using the system. What forms of expansions or improvements might be included in an ideal packet setup? That's strictly a matter of personal preference, and no two cases will be the same. We can highlight a couple of examples, but remember they're just examples to spur your own thinking in the right directions.

If your initial packet pursuit involves VHF 2-meter activities, later expansions could include possibly adding packet capabilities to your separate HF setup. An already crowded setup might be expanded vertically by using an accessory shelf. These are available commercially for amateurs desiring quick convenience over home construction. Check your area's consumer electronic and computer supply stores for VCR, stereo, and video monitor cabinet or desk items.

The two computer ideas mentioned earlier in this chapter are particularly appealing to amateurs setting up separate VHF and HF packet systems. Less expensive and readily available computers are attractive for HF use because they are supported by a wide array of software related to amateur radio. Elaborate software and terminal programs are available for more professional style computers, making them appealing for home business and VHF packet use. The idea here is convenience and flexibility.

Some amateurs enjoy going all out in their pursuits, even to the point of converting an indoor garage or unused home area into a deluxe radio room. Enthusiastic endeavors of this nature might include adding special cork-type walls, acoustic ceilings, elaborate flooring, even new windows and a separate door to the radio room. A packet station could then be placed in one area, and another station could be placed across the room. If you later feel isolated from the mainstream of family activity, another setup could be added to the den or bedroom. Let your imagination and pocketbook be your guide.

Summary

As discussed in this chapter, a packet radio setup can be as simple and basic or as sophisticated and elaborate as one desires. Personal preferences and lifestyles are the keynotes. Naturally, the better one's packet layout, the more enjoyable it is to operate.

Plan your packet setup's layout for convenience and comfort to both you and your computer. A comfortable chair and desk are pleasing to you, and a cool, dry area with clean AC wiring is comforting to your computer. Surge protection for the packet setup should always be included for equipment life insurance. Only minutes before writing that last line, we talked with a local amateur who suffered the loss of several computer chips during today's mild and brief thunderstorm. I wonder how many more amateurs across the country will experience the same thing during the time you're reading this chapter.

Interference to HF and VHF packet radio setups is becoming an increasingly noticeable problem, but personal ingenuity continues to be successful in minimizing those irritations. Metal siding on a building, or directional antennas with their backs toward the interference, often block it successfully. Power line and cable TV noises can also be rectified by conscientiously studying their location and nature before contacting responsible companies.

The Ins and Outs of Packet Radio Operations

After setting up a well-planned and efficient packet radio system, subsequent questions typically fall in the "how do I use it successfully" category. Little written information has addressed this area, mainly because packet radio has grown (and continues to grow) faster than it can be documented. Packet's population usually includes digipeater owners and relatively new packeteers. Digipeater enthusiasts are often too busy with innovations to write newcomer guides, and new packeteers are too involved learning the ropes to help others. In some respects, this situation reminds us of amateur radio many years ago. Newcomers scurried from one experienced amateur to another like squirrels collecting acorns during the fall, picking up every piece of usable information they could. So the basic purpose and objective of this chapter is to explain the techniques and intricacies of packet radio operations in a form that should be understandable to a newcomer. My own qualifications place me roughly midway between a newcomer and an old-time packeteer, plus I have several assets you'll find beneficial. While writing this book (and enjoying packet operations with a wide variety of exciting gear), I attended several major 1986 hamfests and conventions and collected packet information from the experts. My mind was oriented toward you, the newcomer, or the packeteer looking for more information. I also visited and/or talked with other packet radio leaders and asked for their input, as we're expecting this book to be read by many eager to join packet action.

While this chapter's information is extremely useful, we must emphasize that packet radio continues to change and evolve. New ideas and techniques are being implemented each month. Although monthly amateur magazines are necessarily slightly behind changing trends because publishing takes time, they are still a great source of late-breaking news. Dedicated packet radio magazines are another ideal source of information. We thus encourage you

to subscribe to as many amateur radio and packet magazines or newsletters as you can afford. Our collection shown in Figure 7-1, for example, resembles a mail order hamfest during the first of each month.

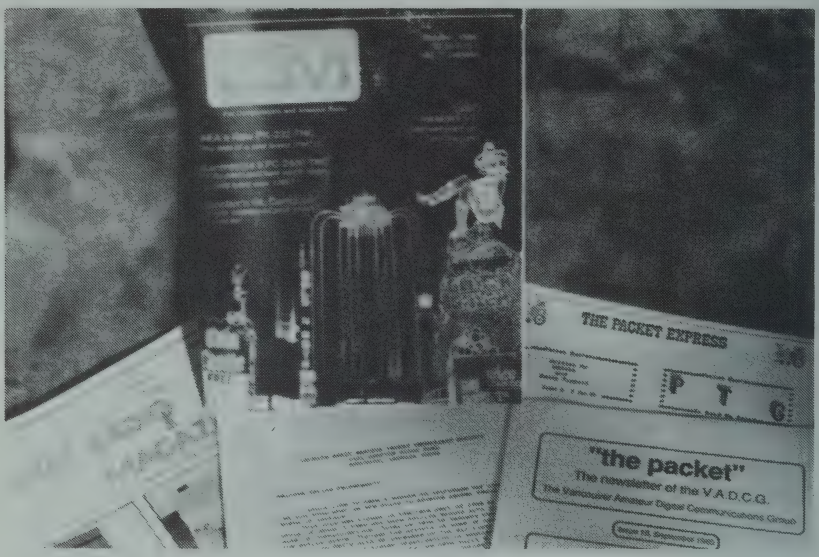


Figure 7-1. Packet radio magazines and newsletters.

Another very important source of packet radio information and newcomer support is provided through the many packet radio organizations nationwide. A brief sampling of national, regional, and local groups follows:

National

AMRAD
P.O. Drawer 6148
McLean, VA 22106-6148

AMSAT
850 Sligo 0601
Silver Spring, MD 20910
(301) 589-6062

TAPR
Tucson Amateur Packet Radio
P.O. Box 22888
Tucson, AZ 85734-22888

California

Los Angeles Area Packet Group (LAPG)
P.O. Box 6026
Mission Hills, CA 91345

Southern Calif. Digital Coordination Council
SCDCC
P.O. Box 6026
Mission Hills, CA 91345

Pacific Packet Radio Society
P.O. Box 51562
Palo Alto, CA 94303

San Diego Packet Group (SDPG)
c/o Mike Brock WB6HHV
10230 Mayor Circle
San Diego, CA 92126

Colorado

Rocky Mountain Packet Radio Association
RMPRA
c/o Andy Freeborn, NØCCZ, Secretary
5222 Borrego Drive
Colorado Springs, CO 80918
(303) 598-8373

Florida

Florida Amateur Digital Communications Assoc.
FADCA
812 Childers Loop
Brandon, FL 33511
(813) 689-3355

Georgia

Georgia Radio Amateur Packet Enthusiast Society
GRAPES
P.O. Box 1354
Conyers, GA 30207

Southern Amateur Packet Society (SAPS)
c/o Wayne Marrell, WD4LYV
Rt 1, Box 185
Sycamore, GA 31790

Illinois
Chicago Amateur Packet Radio Assn. (CAPRA)
P.O. Box 8251
Rolling Meadows, IL 60008

Iowa
Central Iowa Technical Society
c/o Ralph Wallio, WØRPK
R.R. 4
Indianola, IA 50125

Massachusetts
New England Packet Radio Assn. (NEPRA)
P.O. Box 15
Bedford, MA 01730

Michigan
Eastern Packet Radio of Michigan (EPROM)
c/o J. Nugent, WB8TKL
307 Ross Drive
Monroe, MI 48161

Minnesota
Minnesota Amateur Packet Radio (MAPR)
c/o Pat Snyder, WAØTTW
565 Redwood Lane
New Brighton, MN 55112

Missouri
St. Louis Area Packet Radio (SLAPR)
9926 Lewis & Clark
St. Louis, MO 63136

New Hampshire & Vermont
Mt. Ascutney Amateur Packet Radio Assoc.
c/o Carl Breuning, N1CB
54 Myrtle Street
Newport, NH 03773

New Jersey
The Radio Amateur Telecommunications Society
RATS-NORTH
c/o J. Gordon Beattie, Jr. N2DSY
206 North Vivyen Street
Bergenfield, NJ 07621
(201) 387-8896

The Radio Amateur Telecommunications Society
RATS-SOUTH
c/o Brian B. Riley, KA2BQE
RD 2 Burnt House Road
Indian Hills, NJ 08088

Cherryville Repeater Association
Box 308
Quakertown, NJ 08868

New York

Rochester Packet Group
c/o Fred Cupp, W2DUC
27 Crescent Road
Fairport, NY 14450

Packet of New York (PONY)
c/o Bill Schecler
42-15 172 Street
Flushing, NY 11358

Mt. Beacon Amateur Radio Club
P.O. Box 841
Wappingers Falls, NY 12590

Ohio

Cincinnati Amateur Packet Radio
Experimenters Society (CAPRES)
c/o John Schroer IV, KA8GRH
984 Halesworth Drive
Forest Park, OH 45240

Tennessee

John Burningham, WB8PUF
Memphis State University
Dept. of Engineering, Technology
Memphis, TN 38152

Utah

Utah Packet Radio Association (UPRA)
4382 Cherryview Drive
West Valley City, UT 84120

Washington
Northwest Amateur Packet Radio Assoc.
(NAPRA)
c/o John Gates, N7BTI
750 Northstream Lane
Edmonds, WA 98020

Joining and supporting your nearest packet group is both logical and mutually beneficial. Most groups also publish their own newsletters, and they are an ideal means of learning your area's "dos and don'ts" of packet operation.

In many respects, packet radio operations are different from, yet similar to, conventional HF-type operations. Naturally, many newcomers find that statement confusing. As clarification, try to visualize packet radio as a form of wireless telephone network—any operator with a setup available to the network can call others, send or retrieve bulletin board messages, etc. Many packeteers get behind their setups mainly when they have specific calling purposes in mind. In other words, they use packet to fill a particular communications need (during times of emergencies, for example). Other packeteers enjoy reading the mail of various activities, calling related yet unknown stations they find interesting, or even calling CQ if network activity is low. The pleasant mix of these activities keeps packet radio interesting to everyone.

Useful Tips for Newcomers

An often heard yet quite understandable question concerns how one gets rolling on packet radio without looking like a newcomer. Our simplified answer involves general amateur radio courtesy and common sense reasoning. Packet radio is a frequency-shared resource, and we must all operate in a congenial manner to keep traffic moving at an efficient rate. This is known as maintaining a high system throughput. Conversely, systems or networks bogged down with long meaningless messages and unnecessary calls move little traffic and have low throughput (two way QSOs for instance). After getting your packet setup operational, spend a couple of days looking in and reading the mail on local packet channels. Notice how others send brief or single-line messages during busy times, reserving longer transmissions until quiet hours. Notice how CONNect requests or messages that are continuously transmitted and unacknowledged reduce a network's throughput.

That is, two packeteers may be communicating quite efficiently until three or four additional stations begin sending CONNect requests or "I'm not available now" messages. Meanwhile, other stations begin transferring long files of information which further restricts channel use time. Our original two packeteers continue getting their brief messages across, but the time between exchanges increases. Assuming everyone communicates in single line or break-in style (known as using PACLENS less than 64) during busy times, everyone gets their message through rapidly. Packet radio is a group activity, and so depends on courteous operation. With that in mind, numerous QSOs can be conducted in a time-share manner on a single frequency. As you spend time with on-the-air packet activities, reading packet information in monthly magazines and newsletters, and talking with other packeteers via 2-meter FM and during club gatherings, your own knowledge and expertise expands. You're then well on your way to becoming a seasoned packeteer. (We're all newcomers so to speak, since packet radio is only a few years old. We simply have a different point of reference between "new" and "old.")

Are we now ready to join the packet racket? Assuming you now understand all of your monitor's displayed information, let's review a few more commands before getting started. Who knows—five packeteers may recognize your call and simultaneously connect with you during your first QSO, or channel activity might soar and call for changing several TNC operating parameters. Chapter 2 explained the operating parameters in a general way. Let's now consider how some of them can be very helpful to you.

Operating Parameters Reviewed

First off, we suggest studying again your own TNC's operating commands and their default settings along with this text. As previously mentioned, exact commands vary between manufacturers; their functions, however, are very similar. CONMAX, for example, specifies the number of stations that may connect with you simultaneously, and typical defaults vary from one to ten. A newcomer will have his or her hands full with one QSO at a time—five or ten can be catastrophic. Resetting CONMAX (or its equivalent command) to one will keep things under control while telling others you're busy. They'll call again later, or you can note their call on your screen and call them later (I wonder if they'll remember to hold their CONMAX at a workable level . . .).

The MONCON or equivalent parameter of most TNCs defaults or powers up in its "off" state. You can thus copy all on-frequency packet activity only when DISConnected. After CONNection with another station, your monitor displays only those packets addressed to you. Resetting MONCON to "on" lets you copy all those other signals that seemingly appear from thin air. This capability is reassuring when you begin hearing numerous packets coming your way and you're wondering if they're addressed to you.

The previously mentioned signals from thin air, incidentally, may be the result of BEACONING, a previously (and purposely) undiscussed and presently controversial TNC operating parameter. When activated, a TNC's BEACON feature transmits a preprogrammed packet message (BTEXT) that can be copied by all channel users. It can be set to BEACON every number of minutes or to BEACON after any noted on-channel activity. BEACONING was useful during the early days of packet radio, when few stations were active and there was a need to know if other packeteers were on-frequency. Today, however, packet activity is flourishing and there's no doubt of its presence on a frequency. BEACONING today reduces channel and/or network throughput quite noticeably, especially if several packeteers BEACON during the same time. Unless one lives in a remote area, we highly encourage monitoring activity and CQing when necessary rather than BEACONING. With that in mind, we strongly suggest having your BEACON off. That's usually accomplished by setting it to "off" or "zero." Check your specific TNC's manual to be sure.

As packet activity increases on a particular channel, frequency throughput, or the time required for passing each separate packet, decreases slightly. The logical maneuver during those busy times is reducing PACLEN, or the "information" length of each packet to 64 characters or less. Those shortened packets can zip along their path most effectively, and they provide more air time for other short packets to do likewise. As we've previously emphasized, packet radio is a group activity. Everyone shares and everyone fares. You can always send a short packet by including a "K" and carriage return after typing one or maybe two lines of text to be transmitted. The "K" invites the other station to transmit and the carriage return tells your TNC to packetize the message and send it out. Some users type one or two "greater than" (>) signs to signal the end of a transmission. Either way works fine. A PACLEN of 64, however, is a good backup if you forget to tap a "K" and carriage return during QSO excitement. In other words, it keeps a watchful eye in case you make a mistake.

Three noteworthy and interrelated parameters in packet operations are MAXFRAME, RETRY, and FRACK. MAXFRAME sets the maximum number of unACKnowledged packets the TNC will retain in its buffer. If you prepare more messages for transmission, the TNC will not accept them until its outstanding messages are ACKnowledged or their path is DISConnected. Most TNCs default at four; however resetting MAXFRAME to one keeps life simple for you and significantly improves channel throughput for everyone. After each packet is transmitted, its TNC monitors for an ACKnowledgment. If that ACK isn't received within the number of seconds specified by its FRACK parameter, the TNC will RETRY to send the packet. Short FRACKS reflect impatient TNCs and operators, and they add to channel congestion. Patience is a virtue especially when a channel is busy. Changing FRACK from a default of three to eight isn't only considerate, it's the sign of a seasoned packeteer.

The number of times unACKnowledged packets are retransmitted before being declared DISConnected is specified by the RETRY parameter. Usual defaults vary, but a count of ten can really congest an already busy channel. If the other station doesn't ACK within two tries (and assuming sufficient FRACK time for that ACK), eight more retries usually aren't beneficial. Ideally, we suggest checking with your local group to learn their preferences. These tend to vary slightly from state to state and between attended and unattended operation.

Remember Chapter 2's general discussion of DWAIT? This is a selectable time period your TNC waits after hearing the last on-frequency action before it activates your transmitter. Its main purpose is helping to avoid collisions with other packet signals (we called that "doubling" on FM or SSB), and improving channel throughput. For optimum results, check with your local packet group and set DWAIT to an agreeable value. Precise DWAIT settings vary according to an area's activity.

The DWAIT parameter's second cousin is TXDELAY, another variable every packeteer can use advantageously. This is the time a TNC waits after activating a transmitter's push-to-talk line before it sends packet tones to that transmitter's audio input. This delay provides time for the rig's oscillator or PLL circuitry to stabilize and get ready to send tones. It also allows time for the other station's squelch to open. If sufficient TXDELAY isn't provided, the first section of transmitted packets will not be received by other stations or digipeaters. Your packets will thus be incomplete and you'll wonder why your transmissions are not getting through. A crude yet successful means of setting a TNC's TXDELAY to mate with a particular transceiver is as

follows. First, pick a quiet time when your local digipeater isn't busy. Next, be sure you've entered your own call in the TNC's MYCALL parameter spot. Finally, try to CONNect with yourself via the digipeater (example: CONN K4TWJ via K4HAL-2 [return]). If the CONNection is unsuccessful after a couple of RETRYs, change the TXDELAY from its default to its maximum value. If CONNection still doesn't occur, investigate further. Listen to your transmitted signal on a nearby second rig or handheld talkie. Does it sound like a nice clean packet such as you hear from others? Is the beginning clipped off? Next, listen to the digipeater on your main packet transceiver after sending a packet. Although your packet isn't being received on your own setup, be sure the digipeater is relaying your signal. (Your transceiver isn't transmitting −600 or +600 kHz, is it?) Still no relay? Recheck your TNC's manual and add AXDELAY as necessary. This measure, however, is seldom necessary if you're using any style of modern transceiver. We merely mentioned it so you'll know your options and feel confident. After successfully CONNecting with yourself, reduce the TXDELAY count by half its required new value and try DISConnecting. If that DISConnect is successful, your required TXDELAY is between default and half of the new values. If the DISConnect isn't successful, your required TXDELAY is between maximum and half of the new values. Go through the sequence one more time, and you'll have TXDELAY set perfectly. All finished? Now be sure to type "PERM" (if necessary on your specific TNC) so the commands will be permanently retained in your TNC's EPROM.

Table 7-1.
Suggested TNC Parameter Settings of AEA PK64 TNC for Newcomers

Parameter	Function	Typical Default	Suggested Setting
CONMAX	Specifies the number of stations that can simultaneously connect with you	10	1
MONCON	Monitor all or only one QSO while connected	Off	On
BEACON	Transmit a message automatically	Off	Off (always)
PACLEN	Sets character length of transmitted packets	128	64
MAXFRAME	Maximum number of non-ACKed packets in TNC buffer	4	1

Table 7-1.—cont.
Suggested TNC Parameter Settings of AEA PK64 TNC for Newcomers

Parameter	Function	Typical Default	Suggested Setting
RETRY	Number of times non-ACKed packets will be sent	3 to 10	2
FRACK	Frame ACK waiting time (in seconds)	3	8
DWAIT	TNC wait time after last on-frequency activity before transmitting	3	Check your local area's preference
TXDELAY	TNC wait time after transmitter activation before applying packets	4 (each = 40 ms)	8 (varies with transceiver)
MYCALL	Stores your call for addressing and decoding packets	Manufacturer's name or ad	Store your call here before joining the packet action!

Since this discussion of parameter settings and suggestions covered a substantial amount of ground, we've summarized the information into Table 7-1. Note: the examples in Table 7-1 apply to an AEA PK64 TNC. The settings may be different for other types. You can copy Table 7-1 or tear it out and place it on your wall or under your desk's glass for convenient reference and use. In fact, maybe you should pass a copy over to another newcomer as a subtle hint. Now let's move further and consider some points on packet operating etiquette.

On Being a Good Packeteer

We all know and understand that first impressions are lasting impressions, and a new packeteer naturally wants to get started operating with the best foot forward. Since QSO activities capture our attention and enthusiasm during operations, we thus need to visualize where we're going before embarking on the venture.

A possible source of misunderstanding or confusion during a QSO centers around packets crossing along their relayed/digipeated paths (similar to the "letters crossing the mail" syndrome). Station A sends a packet to

Station B. While Station B prepares a reply, Station A sends a second packet. The confusion is further compounded when a string of digipeaters is utilized and packet activity is high. Throughput still exists, but its time increases. The obvious answer is including a human factor in your operations (similar to the FRACK waiting time in your TNC). Give the other station ample time to reply. Maybe he or she is involved in multiple QSOs or received a telephone call. Meanwhile, double check yourself to ensure you're typing calls and digipeat paths properly. Also, be sure to include an obvious "K," "BK," or ">" at the end of your message. That eliminates doubt and notifies the other station you're standing by for his reply. I remember my own first packet QSO. I had everything down pat (I thought), but I received three packets (each with its own "K" at the end) before I could hammer out a reply. Since I thus knew a reply was requested, I merely typed "I'm hurrying . . . QRX." It worked, and the patient fellow waited.

DISConnecting after a QSO concludes may also seem like an embarrassing moment. We surely don't want to seem arrogant, but neither station wants to leave the other in a CONNected state. That's a definite no-no. The solution? At the QSO's end, sign obviously, and add 73, CUL and SK. The other station will be confirmed on your screen as you're signing off and DISconnect. That DISconnect will be confirmed on your screen as "***DISC." Watch for it; it's that simple.

Since interlinked digipeaters are one of packet radio's prime attractions, successful use of that capability is especially desirable to new (and old) packeteers. Assuming you're copying packet DX or multidigipeated stations, your TNC's MONPRT parameter can be activated for determining their paths (see Figure 7-2). It's then a simple procedure to mentally reverse the digipeater paths, program your setup, and CONNect with the desired station. (Digipeater calls are displayed and marked with an asterisk.) This investigative measure is also useful when beginning packet activities in a new area you might find during vacations or weekend trips. Assuming you know or have been informed of a multidigipeater path and want to check its operation, you can try a simple self-connect test (CONN K4TWJ via digipeater 1, digipeater 2, . . . etc.). This requires the CONNect, ACK, and later DISConnect requests go down the path and back, which can be somewhat noticeable and channel/time extravagant during busy hours. Try, instead, sending a nonCONNected or UNPROTO CQ and watch your (DISConnected) monitor for the return. If the path is good, you'll see your packet twice—once when your area's digipeater sends it on down the path and again when it transmits it on the way back. You get the same results, but use less channel

time. Of course, local area QSOs can be diverted from such multilinked digipeater frequencies for also improving throughput and making life more enjoyable for everyone. That brings up our next consideration—spectrum use.

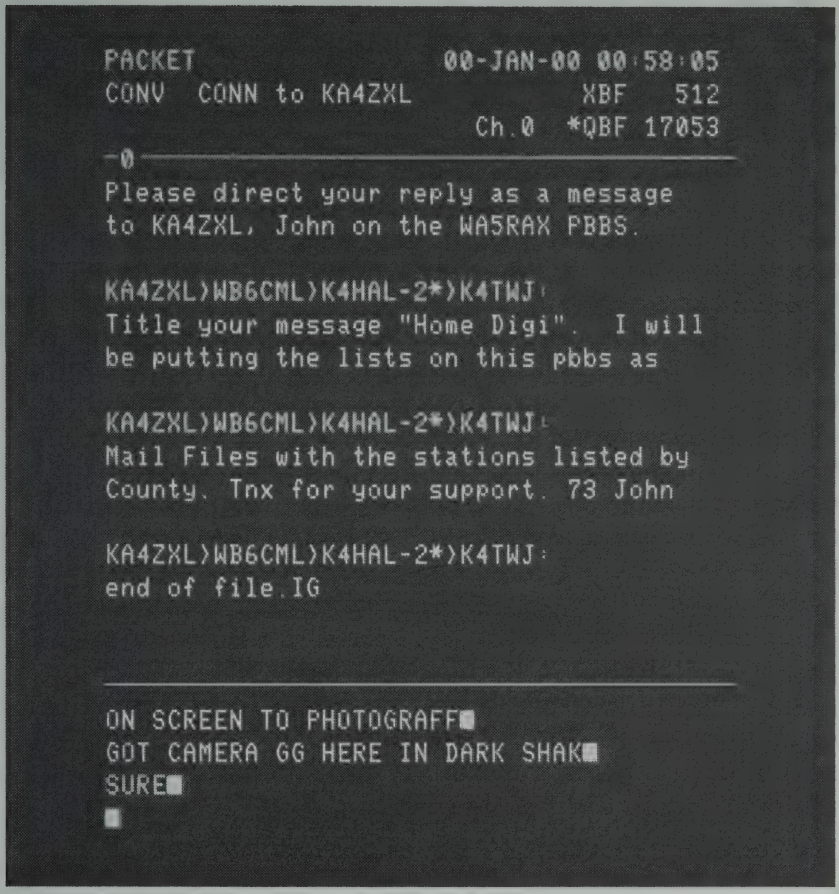

PACKET 00-JAN-00 00:58:05
CONV CONN to KA4ZXL XBF 512
Ch.0 *QBF 17053
-0
Please direct your reply as a message
to KA4ZXL, John on the WA5RAX PBBS.
KA4ZXL)WB6CML)K4HAL-2*)K4TWJ:
Title your message "Home Digi". I will
be putting the lists on this pbbs as
KA4ZXL)WB6CML)K4HAL-2*)K4TWJ:
Mail Files with the stations listed by
County. Tnx for your support. 73 John
KA4ZXL)WB6CML)K4HAL-2*)K4TWJ:
end of file.IG
ON SCREEN TO PHOTOGRAFF
GOT CAMERA GG HERE IN DARK SHAK
SURE

Figure 7-2. Using the TNC's MONRPT parameter to trace paths for calling distant packet stations.

Although packet radio transmissions can be legally transmitted in any range authorized for F1 emissions, a general gentlemen's agreement of 2-meter packet frequencies exists throughout the country. 145.01 MHz is, naturally, the main (and busiest) frequency. It is the prime route of DX and intracity digipeaters (except for high speed 220/440 MHz trunks and other special innovations that may be started in the future). The frequencies or

channels of 145.03, 145.05, 145.07, and 145.09 have been accepted by gentlemen's agreement for local area use. We should also mention that some local areas elect to do their own thing and use specially adopted frequencies. Check with your local packet group! Whenever possible, use a local area channel or frequency for direct packet QSOs (when you can communicate with the other station without the aid of a digipeater). This measure makes life easier for everyone (including you) by minimizing channel sharing and improving throughput. The main 145.01 MHz frequency can be used for monitoring and calling while the other frequencies can be used for QSOs or (especially) exchanging long files. You can initially establish contact and CONNect with another station on 145.01 MHz, then shift to another frequency without breaking the CONNection. Each operator merely reaches over, changes transceiver frequencies, and continues preparing and reading packets. Some areas also include traffic directing digipeaters on their secondary packet frequencies—another good idea. If you can communicate successfully on a direct or nondigipeated frequency, great. Otherwise, you can switch to a local area digipeated frequency. If that digipeater is linked back to 145.01 MHz, you can also enjoy DX QSOs without unnecessary throughput delays. Of course, there will be many times when your QSOs cover long distances, and multilinked 145.01 MHz digipeater use will be necessary. That's when the operating guide in Table 7-1 is quite useful.

Roundtable QSOs and/or informal network meetings can also be conducted quite successfully via packet radio. This capability is especially appealing during times of emergency or when providing communications for special public events. Any or all packeteers can monitor the action using the DISConnected state of their setup. There are also several ways one can join in that action if desired or necessary. One of the easiest ways of setting up a roundtable involves packeteers pairing up and CONNecting with each other, with their MONCON (monitor/display all on-frequency activity while CONNected) parameter switched "on." Everyone then reads everyone else's mail. A simple way for additional stations to join such an activity in progress is by merely CONNecting with themselves via the roundtable's digipeater(s). Packet radio, incidentally, is an ideal way to move vast amounts of public interest information at an extremely rapid rate. Data regarding health and welfare, for example, transfers like computer printouts and is available to CONNected and DISConnected packeteers alike. Imagine its use during a crisis, then understand why major traffic normally routes via 145.01 MHz while secondary traffic diverts to other packet channels when possible.

Roundtable or multiCONNect-type packet activities can become quite involved and time-consuming in nature. No one finds that objectionable during emergencies or if they're an active part of the roundtable. Otherwise, mail readers or light channel users may find such continuous action distracting. These are the times when the BUDLIST parameter discussed in Chapter 2 may prove beneficial. Other stations' use of a BUDLIST can also explain why you always receive a "busy" response to CONNect requests or seem to be ignored during roundtable QSOs. Likewise, all packeteers don't stay glued to their setups during operation. Some folks program the system, then return to the room occasionally and read their incoming buffer messages. Remember that packet radio isn't necessarily a real-time mode. That advantage is especially noteworthy among serious bulletin board system users, which leads to yet another subject (. . . and another chapter). Since bulletin board systems are a form of packet radio operations and although our upcoming chapter will include a detailed study of BBSs, a brief overview at this time seems logical.

A bulletin board system is similar to an electronic post office or public bulletin board setup. It's accessible twenty-four hours a day, and it allows you and your friends to leave and retrieve messages any time you desire. Easy-to-learn commands let you read messages, review general bulletins of interest to the whole amateur community, and basically keep you informed on what's happening, all at your convenience. You can review ARRL bulletins, DX newsheets, propagation forecasts, OSCAR orbital predictions, or leave daily notes for friends. BBSs are basically easy to use and understand, but since their role in packet radio is so far-reaching (literally . . . some BBSs offer worldwide capabilities), their full story is contained in an upcoming chapter.

Summary

As previously discussed, packet radio is a shared resource. No one stands alone in this game. Each packeteer has a direct influence on a network's overall performance and the network's effectiveness to its area. New packeteers are encouraged to join and support their nearest packet radio group. Likewise, subscribing to packet newsletters and supporting amateur magazines will keep you informed of timely developments in this rapidly changing area.

New packeteers are encouraged to spend plenty of time reading the mail and learning the use of their TNC's operating parameters before jumping into the action. A TNC's operating commands provide an unbelievable degree of flexibility; indeed, you can tailor your system exactly to your taste merely through operating parameter selections.

Since each packeteer wants to get started on the right foot, always stay alert to the desires and needs of others. Whenever possible, use direct/simplex frequencies to give maximum throughput for you and your friends. When transferring long lists or data via digipeaters, set your TNC so you'll have lowest channel priority. That will let others get packets in edgewise, and you can take a break while your input buffer loads. Whether QSOing others, reading mail or reviewing BBS information, patience is a priceless virtue. Don't rush the action. Although 1200-baud 2-meter packet operations move data more than 1400 words per minute (and that's FAST), more users mean more time.

Casual packet radio operations are truly enjoyable and beneficial, but amateur radio's ultimate purpose is always public service. This fact is vividly reflected during times of need and/or emergency. Packet radio is truly a valuable resource in that situation. May that fact always remain foremost in our minds. A couple of portable packet radio setups carried into a disabled area could fill several bulletin board systems with important information available to everyone. If that information is being transferred on a digipeater by any one involved packeteer, it can be reviewed by all other packeteers merely by mail reading in the DISConnected stage. Simply having packet radio capabilities available for a time when they may be needed should indicate its benefits to all radio amateurs.

Packet Networks, Bulletin Board Systems, and HF Operations

As you'll surely agree, we've covered a substantial amount of ground in our discussion of packet radio. We've investigated the "whys and hows" of the packet revolution, its basic concepts and its technical intricacies, the amateur gear and computer market addressing packet radio, plus how to set up and operate a packet station. Using that knowledge as a solid foundation, let's now focus on a greater understanding of packet radio's special attractions and activities. The combination of basic discussions and expanded views will provide a smooth overall picture of the packet radio world as of late-1986. This chapter will investigate the inner aspects of networking, bulletin board systems, store and forward electronic mailboxing, and HF packeting. In later chapters we will delve into portable packet systems for traveling and emergency use, amateur satellites supporting packet capabilities in a "flying mailbox" manner, and conclude with some interesting views of the future.

Since the world of packet radio includes numerous specialized operating capabilities, there's a natural inclination to bypass or overlook its basic applications and go for the excitement. While such reasoning is human nature, let's not ignore the communications possibilities of two simple packet setups. Even without digipeaters or bulletin boards, packet radio is an ideal and convenient means for leaving notes with local friends. Assuming packet systems are set to monitor a mutually agreeable local frequency, such note passing does not depend upon real-time monitoring. Station A passes a note to Station B, for example. ("Just finished the new rig. Want to meet at Joe's Cafe tomorrow at noon for a look? Leave reply before 7 A.M. tomorrow.") Some hours later, the operator of Station B reviews buffer-stored messages and leaves a reply. ("Already promised local DX gang we would meet them at 12:30 at Pizza Hut on 20th South. Come join us there. Leave reply before 7:15 A.M.") This operation may have seemed simple, but it served a definite

purpose. Likewise, such note passing is perfectly suited for amateur families with busy daily routines, or for moving information during community activities or emergencies. If one stays alert to happenings around them, numerous applications for packet-type capabilities become apparent.

Thinking further along such lines opens even more possibilities for entrepreneurs—installing packet-type systems for government or law enforcement agencies, cellular mini-packet systems for diverse businesses . . . the list is endless. Since the system uses audio tones that can be transferred via existing business band radios, the hard work has already been performed. This could be a lucrative pursuit for enthusiastic home business devotees.

Now let's turn our attention toward expanding our horizons and using packet's networking capabilities to cover greater distances. Such interlinking arrangements may be instigated on the city, state, or international level, depending on our packeteer's needs and desires.

Network Capabilities and Limitations

As discussed in previous chapters, packet radio's use of the AX.25 protocol is the keynote to its multistation interlinking and networking. This multilayer protocol can specify up to eight relays between its points of origin and destination. When combined with optimum locations and/or HF or OSCAR gateways, those eight relays can pass a signal around the world. Conversely, eight poorly located VHF relays can limit linked range to 300 or 400 miles. These points are mentioned to give you a working idea of the range capabilities and limitations you can expect with VHF-based packeting. While every packet setup includes the capability of receiving and retransmitting packet messages from others, those relays are usually accomplished by strategically located digipeaters. A chain of such digipeaters can pass messages over great distances while each packet station (specifically, each station's TNC) monitors every transmission to determine if that transmission is addressed to it. The limitation here is that error-checking and ACKnowledging are performed on an end-to-end basis; that is, both packet message and parity data must travel the chain's length, then ACKs must return back down the chain. Naturally, greater amounts of traffic decrease throughput (high volume systems are presently being developed to handle ever increasing packet traffic levels).

Although conventional FM voice repeaters can be used to relay packet radio signals, such actions usually aren't favored by local ragchewers

(better known as risking being hung by your coax). A digipeater is more logical and efficient because it is a single frequency or simplex repeater, and it's dedicated to digitized signal operations. It receives and stores a full packet transmission, then immediately retransmits it on that same frequency. As illustrated in Figure 8-1, digipeaters are quite simple in design—a TNC and one transceiver operating on one frequency are all it takes.

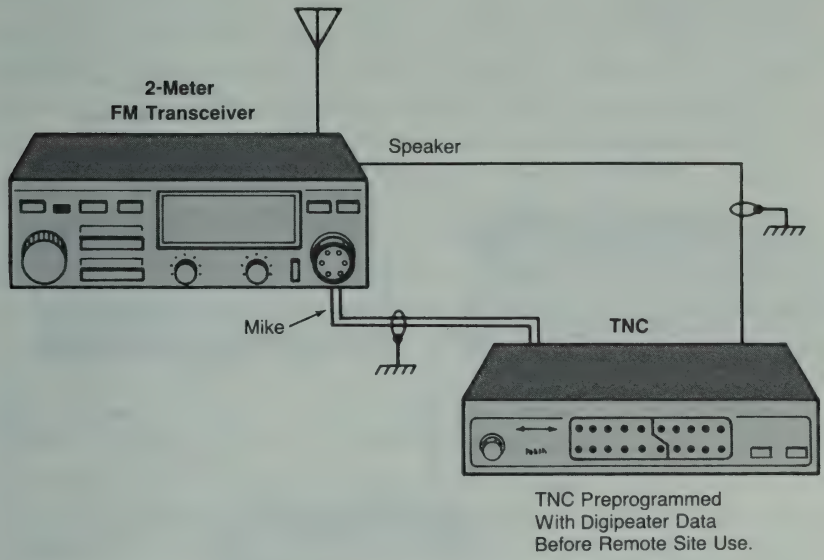


Figure 8-1. Basic equipment arrangement of a single frequency digipeater.

Moving in a slightly more sophisticated direction, many areas are finding use of dual-port digipeaters quite beneficial. As shown in Figure 8-2, dual-port digipeaters use two transceivers operating simultaneously on different bands and an intelligent "TNC-crossed computer." This type of digipeater can be used to recognize and move outgoing traffic off heavily used local frequencies and onto UHF "trunks" or "backbones" feeding specified distant destinations. At the distant end, a similar setup is used to move the trunked packets off the backbone and back onto a local frequency for dispersion. The overall concept might be compared to a state freeway handling a volume of travelers in autos while bypassing metropolitan areas until reaching their destinations; that is, you get on in one area, possibly accelerate while enroute, then hop off and slow down to local speeds. In our case of packet messages,

we are not concerned with exact speeds or collisions along the hypothetical freeway, but only that an accurate copy (not necessarily an original) of the message is exchanged. The obvious purpose of such packet trunking is twofold: reducing network loading, and increasing transmission speeds. Both factors improve overall throughput.

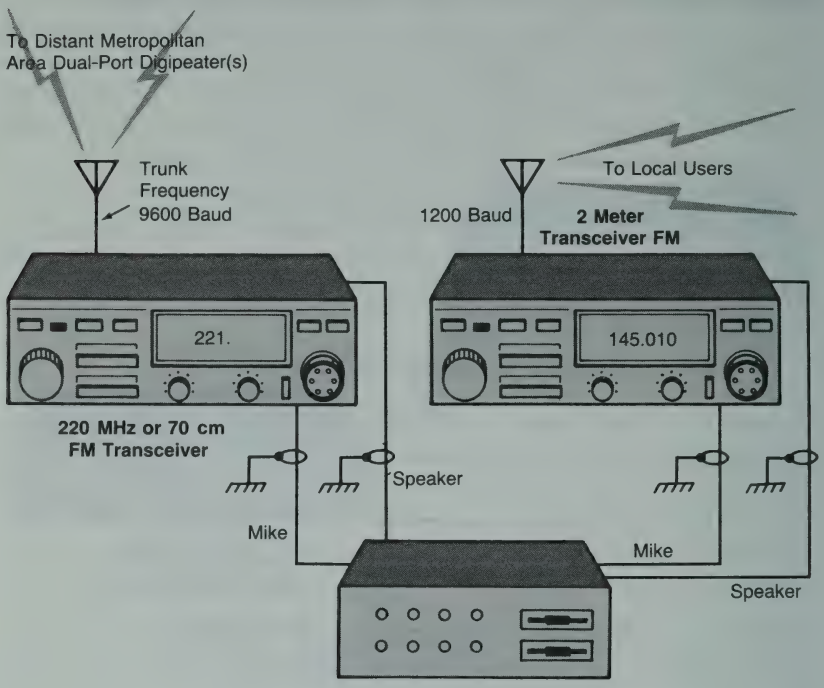


Figure 8-2. Basic equipment arrangement of a dual-port digipeater setup.

An interesting way of visualizing regular packet network loading and throughput is with an analogy to autos traveling on two-lane roads with several checkpoints along the way. When traffic is at an absolute minimum, one can realize maximum throughput by breezing through checkpoints and moving on to a destination. As greater amounts of bi-directional traffic fill the roads, checkpoints become bottlenecked and the average time of throughput decreases. As travelers carry larger amounts of baggage, checkpoints become even more entangled. If everyone drove sports cars with a single suitcase in its trunk, throughput would increase. On the other hand,

a bottleneck would be created by large and heavily packed trucks. Now let's relate some of these ideas to packet radio. Maximum throughput corresponds to light loads during quiet times such as midday or after midnight. Traveling light during busy times is similar to holding PACLENS below 64 characters and thinking efficiently; that is, avoiding unnecessary end-to-end signal transmissions whenever possible. While each operator can noticeably influence a network's overall efficiency merely by a change in planning or software, upgrades of hardware and network designs are also extremely beneficial. That's where UHF trunks or backbones with their higher data speed rates come into play. They allow less traffic, faster travel, and greater network throughput. Lower baud rates on local area networks maintain compatibility with existing in-field setups, unless everyone increases speed at a specific agreed-upon time (which is possible, but not too probable). These are the present arguments favoring AX.25 level 3 and level 4 protocol/network expansions, something you'll be hearing more about in the future. How near that future is, is only speculation at this time but judging by packet's overwhelming popularity and growth, mid- to late-1987 seems logical for its widespread installation. The transition will not be radical. Indeed, end users may not realize significant differences. Their packets, however, will move via bulk-handling switches that will route messages along specific directions determined by network switches instead of spraying RF in all directions as is presently the case. In many respects, such innovations resemble the extensive growth of freeways and the continuous expansion seen in prospering municipalities. In the same way that those views reflect the financial success of state or local areas, packet's continuing constructions reflect its prospering success to sharp-eyed manufacturers.

Network Maps: Plotting a Path

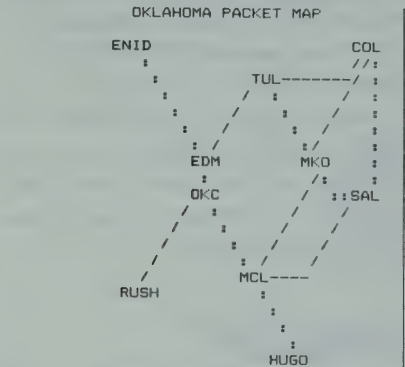
One of the most popular ways of visualizing packet networks of various areas and following their growth is with network maps. This technique is only beginning to gain a foothold as this book is being written, consequently very few network maps have been drawn or exchanged. That situation will surely change within the next few months, and thus bears watching. Two logical sources of such network maps are packet newsletters and *CTM Magazine*. In fact, the packet network map samples shown in Figures 8-3 and 8-4

were prepared by contributor James Larson, WB4KQQ, and appeared in September 1986 *CTM* (*CTM Magazine*, 1704 Sam Drive, Birmingham, AL 35235).

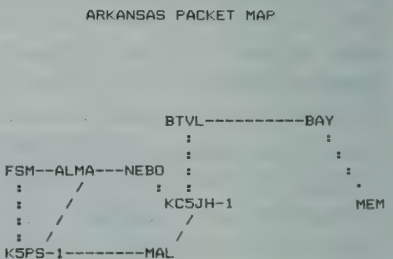
Another possible source of network maps is your local BBS. They will be listed under "files." Alternately, you can gather information from other packeteers while including your own off-the-air observations and make your own network maps (remember to share copies with others). Network maps are great items, but they have a drawback—inaccuracies. Charting packet radio's phenomenal growth can become a daily affair. Don't worry, however, because although digipeaters may be added to network maps, few digipeaters are deleted from those maps.

Legal Aspects

During the early part of 1986, the Federal Communications Commission issued a Notice of Proposed Rulemaking that would preclude packet networks

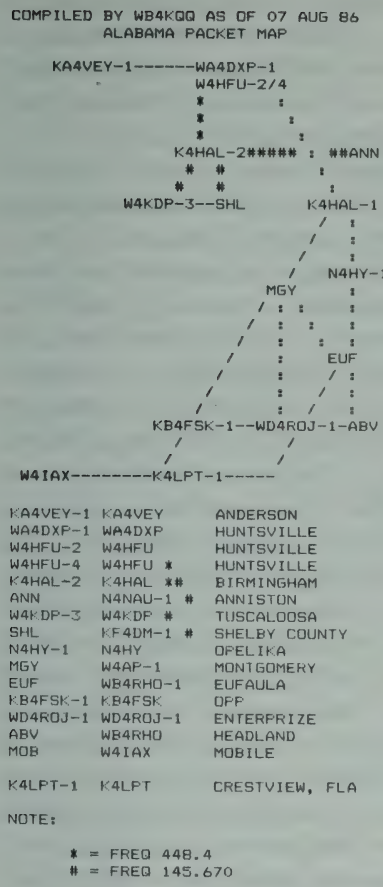


COL	WA5NRT-1	COLCORD, OK
EDM	N5BUJ	EDMOND, OK
ENID	WB5RRR-1	ENID, OK
HUGO	WB5TTU	HUGO, OK
HGO-2	WD5FUE	HUGO, OK
OKC	KD5TS	OKLAHOMA CITY, OK
MCL	??????	MCALESTER, OK
MKO	WB5AOH-1	MUSKOGEE, OK
RUSH	WB5YTO-1	RUSH SPRINGS, OK
SAL	WB5HLR	SALLISAW, OK
TUL	WA5LVT-1	TULSA, OK



ALMA	K5VR	ALMA, AR
BAY	NA5I-1	BAY, AR
BTVL	KA5PWY-1	BATESVILLE, AR
FSM	KG5K	FORT SMITH, AR
KC5JH-1	KC5JH	LITTLE ROCK, AR
NEBO	K5PXP	RUSSELLVILLE, AR
K5PS-1	K5PS	MENA, AR
MAL	WD5JPG-1	MALVERN, AR
MEM	WB4KQQ-1	MEMPHIS, TN

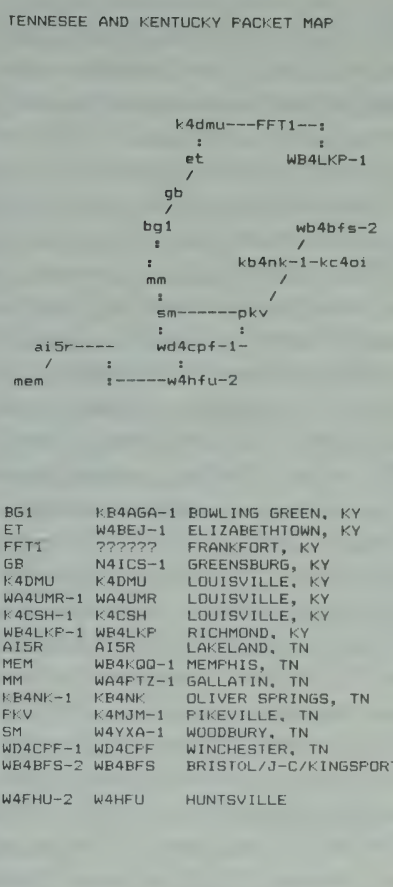
Figure 8-3. Preparing your own network maps involves using your TNC's MONRPT capabilities, exchanging acquired information with others, and plotting resultant paths.
(Courtesy WB4KQQ and CTM Magazine*)*



KA4VEY-1	KA4VEY	ANDERSON
WA4DXP-1	WA4DXP	HUNTSVILLE
W4HFU-2	W4HFU	HUNTSVILLE
W4HFU-4	W4HFU *	HUNTSVILLE
K4HAL-2	K4HAL **	BIRMINGHAM
ANN	N4NAU-1 #	ANNISTON
W4KDP-3	W4KDP #	TUSCALOOSA
SHL	KF4DM-1 #	SHELBY COUNTY
N4HY-1	N4HY	OPELIKA
MGY	W4AP-1	MONTGOMERY
EUF	WB4RHO-1	EUFAULA
KB4FSK-1	KB4FSK	OPP
WD4ROJ-1	WD4ROJ-1	ENTERPRIZE
ABV	WB4RHO	HEADLAND
MOB	W4IAX	MOBILE
K4LPT-1	K4LPT	CRESTVIEW, FLA

NOTE:

* = FREQ 448.4
\# = FREQ 145.670



BG1	KB4AGA-1	BOWLING GREEN, KY
ET	W4BEJ-1	ELIZABETHTOWN, KY
FFT1	??????	FRANKFORT, KY
GB	N4ICS-1	GREENSBURG, KY
K4DMU	K4DMU	LOUISVILLE, KY
WA4UMR-1	WA4UMR	LOUISVILLE, KY
K4CSH-1	K4CSH	LOUISVILLE, KY
WB4LKP-1	WB4LKP	RICHMOND, KY
AI5R	AI5R	LAKELAND, TN
MEM	WB4KQQ-1	MEMPHIS, TN
MM	WA4PTZ-1	GALLATIN, TN
KB4NK-1	KB4NK	OLIVER SPRINGS, TN
PKV	K4MJM-1	PIKEVILLE, TN
SM	W4YXA-1	WOODBURY, TN
WD4CPF-1	WD4CPF	WINCHESTER, TN
WB4BFS-2	WB4BFS	BRISTOL/J-C/KINGSPORT
W4FHU-2	W4HFU	HUNTSVILLE

Figure 8-4. Special codes or symbols added to basic network maps to illustrate frequencies and marginal paths.
(Courtesy WB4KQQ and CTM Magazine*)*

under automatic control from transmitting third party traffic. Such multiple relays could only be allowed under the supervision of a control operator. The FCC's intention in that rulemaking was to ensure that amateur frequencies and facilities were not used by outside influences. As it specifically stated: "Only a person who has demonstrated the proper qualifications may be a control operator. Such control operators screen any third party traffic to prevent transmissions prohibited by the rules." Unfortunately, no one could find a suitable operator with the ability to read and evaluate packets moving

at 1400-plus words per minute, or leap tall buildings in a single bound, etc. The dilemma of possibly disallowing the use of any unmonitored digipeaters, spelled doom for packet radio even before its benefits could be proven. Panic struck. Wasn't our purpose the advancement of technology? Shouldn't rules be amended to accept state-of-the-art advancements?

Petitions of reconsideration from packet groups, individuals, and the American Radio Relay League flooded FCC offices. Without modification regarding third party traffic, packet radio was stifled. During early April, 1986, the FCC thus incorporated a waiver and amendment in their rules to permit continued use and growth of packet radio. Essentially, the FCC's modifications redefined the "control operator" as it relates to packet radio as being the licensed radio amateur intitially entering traffic into a network. Indeed, such traffic originated by amateurs, text controlled by those amateurs and destined for other amateurs would not actually be third party in nature. The amateur starting a packet on its way must make sure that it isn't commercial in nature and that it complies with FCC amateur radio rules. This measure places the ball back in our court for subsequent moves while the FCC studies how well we use the networks. Pending later review of those findings, the FCC requests that packeteers act conscientiously, use but not abuse packet privileges, and keep an eye open for nonamateur or other hacking abuse of networks. This does not mean packet radio can't be used for emergency operations—indeed, that's where packet really shines. It simply means, for example, that packet can't be used by the news media for relaying stories to their headquarters. Packet's continuing growth, along with refinements such as level 3 and level 4, is helping to build an immunity from nonamateur access. Every packeteer is urged to make sure that packet's use continues to be of an amateur related nature. In that way, we're ensuring our own future and continued existence.

The Bulletin Board System

As briefly discussed in the previous chapter, the operation of bulletin board systems or BBSs makes for some of packet radio's most exciting daily activities. Indeed, the capability of passing notes and information to others by a continuously available storage medium is an attraction that's difficult to equal. Needless to say, owners of bulletin board systems have their hands full providing this popular service to the amateur community. Amateur packet radio bulletin board systems are an electronic equivalent to the physical

bulletin boards often seen in grocery stores or community halls. Not only are packet BBSs used as message drops among packeteers, but they also include special features such as newsletter readouts, satellite information, etc. Some BBSs even include a variety of interactive features such as computer games, programmable calculations, and more. The term bulletin board system was used rather loosely in the previous description, so now let's break it down into specific categories for greater understanding.

The first and most popular system used in packet radio is the electronic mailbox. This message storage and retrieval system allows one amateur to leave a message for another amateur, a group of amateurs, or the whole amateur community. The messages are usually brief—not lengthy newsletters or long files. Each stored message is addressed by calls or names so it can be easily displayed when reviewing the contents of a mailbox. After a specified party has reviewed a message, they cancel its mailbox storage and leave a similarly encoded reply. A packeteer accessing a mailbox is typically greeted by a brief list of commands, a Help note, and numbers of the most recent messages left in the mailbox. Depending on the system's design, it may recognize the signing-on party and list the awaiting messages, or it may refer the user to a Help list. Electronic mailbox systems are found in most packet active areas, and many of those systems forward messages to other mailbox systems on a daily basis.

A true bulletin board system is a combination electronic mailbox and file serving setup. A file server stores and retrieves long readouts such as newsletters, reports, and bulletins. Typical examples of such files are the W5YI Report, Westlink Newsletter, W1AW bulletins, etc. Since this system includes both message and file storage, notes are often placed in mailbox sections describing information in the file area.

An expanded and quite sophisticated version of the bulletin board system is a Host system. Packeteers accessing a Host system work directly with its computer as if they were sitting in front of its keyboard. They can run computer games, or sophisticated programs for antenna designing or OSCAR satellite tracking, etc. Since substantial amounts of air time are utilized during Host CONNects, their prime use time often coincides with quiet packet hours. The interesting (and attractive) aspect of these systems is their availability to all packeteers; they can be used after learning a few basic commands, and you can't destroy a BBS with a wrong command.

Using Bulletin Board Systems

As you've surely noticed during brief packet operating stints or while mail reading, bulletin board systems are a perfect medium for keeping in touch with friends and staying in touch with current events. If you're like most newcomers, however, your BBS experiences thus far have probably been confined to watching BBS activities accessed by others rather than trying it out yourself. That attitude is quite understandable, but rest assured BBSs are actually friendly systems with genuine radio amateur operators like yourself. They're quite congenial, actually, although their initial command codes can seem a mite intimidating. BBSs spend a great amount of time on the air (typically, 24 hours a day), so they must present a good image or set a good example for others to notice. In packet radio terms, that equates to efficiently sending the greatest amount of information in the shortest time possible and sharing channels. Only one packeteer at a time can CONNect with a BBS (however, all packeteers can read that mail); consequently, long BBS transmissions are avoided. Keeping that in mind, let's take a closer look at BBS operations.

Checking into a BBS is usually as simple as CONNecting with its station callsign. Remember to include "Via XXX" if a digipeater path is required for accessing the BBS. A good packeteering note here: don't DX a BBS. That is, don't link through more than one digipeater to reach a distant BBS. If you're trying to pass a message to a distant amateur, let your local BBS forward the message to that amateur's local area BBS. Likewise, remember to leave information at the end of the note explaining the return route. For example: [message/text] RSVP; Route to K4TWJ is via WA5RAX mailbox.

After CONNecting with your area's BBS, you'll probably receive a response similar to that shown in Figure 8-5. The first line may vary slightly according to its system operator's (SYSOP) preferences. The second line states there are twelve messages available for review, and the last one is referenced as 190. Every BBS message receives a sequential number. The next stored message will be number 191. The third line asks for your first name . . . a personalized feature. The fourth line offers a menu or Help explanations for first-time users. Entering an "H" (Help) typically results in a response similar to Figure 8-6. As shown, this explains some of the BBS's capabilities and how they are accessed. Assuming your packet system's printer is activated, you can later print this information and place it on your desk for future reference and use. Typing a "return" on your system then shifts the BBS back to normal use, and you get a response similar to lines

six and seven of Figure 8-5 (with your call listed before "de," naturally). The BBS is then ready for additional use. The commands have been abbreviated to single letters for efficiency; an explanation of those commands is included in Figure 8-7. The B/Log out command is first, and serves as a reminder to sign out after use. The Gateway command may vary with different BBSs. Most of the other commands are self-explanatory. Remember to issue only one command at a time and allow the BBS time to respond. One note on ". . . commands that apply to file transfers": these are usually long files, newsletters, or bulletins. Courteous operating encourages limiting them until periods of low packet activity, that is, quiet hours. Meanwhile, regular (shorter length) BBS messages can be transferred.

```
WA5RAX MailBox/Gateway-Jim in Bessemer, ALA.
12 active messages - Last message on system is #190
Use N firstname (return) to enter your name.
Type X (return) for menu with explanations, H (return) for
help.
XXX  de WA5RAX BB$
(B,H,I,J,N,P,T,X,K,L,R,S,D,U,W))
```

Figure 8-5. Typical opening response received after CONNection with a BBS.

After a packeteer has logged on and off a BBS, his or her call and name are stored as a "user" of that system. This provision is employed in store-and-forward (to another BBS) operations. Each BBS with store-and-forward agreements with another BBS maintains and exchanges user lists (or their SYSOPs perform the favor). When a BBS performs its late night traffic exchanging, it reviews the forwarding lists to determine what goes where for whom and acts accordingly. Your message for John might go to a southern BBS, while your message for Jack might go to a northern BBS. Meanwhile, messages to you might be received from a western or eastern BBS. The next day, they're in your local BBS and awaiting your log on and review. Remember, it's your responsibility to cancel messages addressed to you after you review them.

Although variations in these operations will be noted in some areas, the general concepts of BBS use are essentially the same. Most BBSs are copies of the ever-expanding and improving WØRLI system, which simplifies

```
  Simple commands consist of one or two letters and a
RETURN. The second letter of a command is called a qualifier
Some commands accept further arguments. To add an argument,
type a SPACE after the command or qualifier and then type the
argument(s). DO NOT put a space between a command and
a qualifier.

  For example--The ``L'' command list the messages in the
mailbox. Type just ``L'' and a RETURN to list all the
messages entered since you last logged in.

  To list just the messages addressed to you, type ``LM'' and a
RETURN. (The ``M'' stands for ``Mine.'' To list onl messages
higher than a particular number, such as 325, type ``L 325''
don't forget the space.

Some other examples:
  SB to send a bulletin.
  LM to list only messages addressed to you.
  LB to list only the bulletins.
  LT to list only NTS traffic.
  R 3 to read message 3.
  K 5 to kill message 5.
  S WORLI to send a message to WORLI
  SP WORLI to send a ``private'' message to WORLI

  A description of how to use the BBS is in the file
BBS.DOC
Use the D command to download this file:

D BBS.DOC

Please leave any comments as messages to WA5RAX
Good Luck,-Jim
```

Figure 8-6. Typical BBS response to a Help request.

their use and the learning process involved. Packet bulletin board systems are a fantastic communications tool, so go ahead and get involved with them. Tomorrow's emergencies may depend on your expertise acquired today.

Packet Radio Gateways

Sharp-eyed and mentally alert readers may have noticed our previous illustration's reference to gateway operations on a BBS's menu. That reference hinted at yet another packet radio attraction, but gateways are not necessarily

confined to or included in any or all BBSs. Many SYSOPs have their hands full providing BBS-only functions, while other multimode amateurs are more interested in sharing their insights with others than running a BBS. Every amateur fills a particular niche in the world of packet radio.

Essentially, gateways are communication changeover points that extend packet radio's range while providing some unique operating features. Gateways are set up by amateurs operating both VHF packet and HF or OSCAR packet communications. That operator interconnects his or her setups and invites others to enjoy their use during particular hours or events. After gateway connection, the VHF packeteer generally operates in a normal manner while the gateway operator provides any required receiver or transmitter tunings and antenna positioning. The dual action opens several fascinating capabilities truly worth experiencing. If gateway activity is offered in your area, give it a try.

Gateway operations (and operators) usually interface their two related packet radio systems at the audio level for both convenience and compatibility. HF packeting typically utilizes 200 Hz and narrow audio tone shifts, for example, while satellite packeting uses PSK (phase shift keying) and wide or narrow signal bandwidths. The easiest way to interconnect them is to simply use demodulated information from one to modulate the other system's transmitter. In the case of HF gateways, its SYSOP makes sure the HF setup stays on frequency and adds amplification or antenna readjustments to keep the operations rolling smoothly. OSCAR satellite gateway SYSOPs have a slightly more involved role, as they must follow Doppler shifts and spin modulation variations while also performing amplification and antenna changes. These basic factors explain why many gateways are not usually available for open use 24 hours a day. SYSOPs aren't always at their station, bands are not always open, satellites are not always within range, and third party restrictions always apply. Gateway users are considered third parties, and license classes must be known in order to avoid Technician licensees from being relayed on nonrepeater bands such as 20 meters. Since many of these responsibilities fall on SYSOPs, they are required to be at their stations during gateway operations. When everything does come together, however, using a gateway is an ideal method for testing new waters before equipping one's station and joining a particular activity. Of course, the use of gateways can motivate an operator to go further, and that's why we've included a separate chapter on satellites.

B - Bye, log out of the MailBox.
Forced if no response to a menu in 4 minutes.

G - Activate the GateWay.

H - Display the help text.

I - Display information about the system.

J - Display the calls of stations recently heard or connected.

N - Change/Enter your name.
Argument - First name (12 character limit)
Allows you to enter your name into the User file.

P - Show path.
Argument - Callsign.
Shows last connect path for Callsign.

T - Talk to Sysop. Dings the bell on the local terminal.
Gives up after one minute, or input from the TNC.

X - Toggle between the short and long form of the menu.

. . . **Commands that apply to messages:**

K - Kill a message.
Qualifier:
T - Used to kill traffic after it is taken.
Argument - Message number.

L - List message headers.
Qualifier:
None - List all messages entered since you last logged in.
A - ARRL bulletins only.
B - General interest bulletins.
L - List the last N messages.
M - List the messages addressed to you only.
T - List NTS traffic only.
> - List messages TO call given as argument.
< - List messages FROM call given as argument.
@ - List messages @ call given as argument.
Argument - Number of the oldest message to list.
For LL, the number of messages to list.
For L@, L<, and L>, the call.

R - Read a message.
Qualifier:
None - Read one message.
M - Read ALL messages addressed to you.
Argument - Message number to read.

Figure 8-7. Explanation of typical

S - Send a message.
Qualifier:
None - A general message.
B - A bulletin.
P - A private message.
T - Traffic for the NTS.
Argument - Call of addressee.

The form: "S call1 @ call2" is also supported.
call1 is the addressee, call2 is the bbs to forward
the message to. Example: SP K1KSY @ WØRLI

...Commands that apply to file transfers:

The MailBox expects standard filenames:
8 character maximum name, 3 character maximum extension.
Examples: DOC.TNC HFCALLS.HRD CALLS.HRD

D - Download a file FROM the MailBox.
Argument - Name of file to transmit.

U - Upload a file TO the MailBox.
Argument - Name the file will have.
Terminate the file with ^Z (CTL-Z).
You may also terminate the file with /EX as the beginning of any line.

W - What files are available.
Qualifier:
N - List only new files since last login.
Argument - If present, filespec to list.

...Commands on the GateWay menu:

B - Bye, log out of the MailBox.

C - Attempt a connection.
Argument: Call of station to connect to, may include digipeater routing, for example:
C N1CB via KD2S-1,WA1TLN-1

J - Display the calls of stations recently heard or connected.

U - Call CQ. Whatever you transmit will be transmitted through the other TNC in UNPROTOCOL mode.

R - Return to the MailBox (Discontinue GateWay operation).

BBS operating commands.

HF Packeting

After a direct exposure to the world of HF packeting, possibly via a gateway setup, many VHF packeteers elect to include those capabilities in their own setups. That idea is very logical, especially if one is located in an isolated area and wants to enjoy amateur radio activities fully. Likewise, some amateurs simply prefer the feel of unpredictability that's associated with communications dependent on the ionosphere . . . riding the waves of ether like surfers riding the waves of Maui. John Vanden Berg, VE3DVV shows us how a well-equipped HF packet setup looks in Figure 8-8.

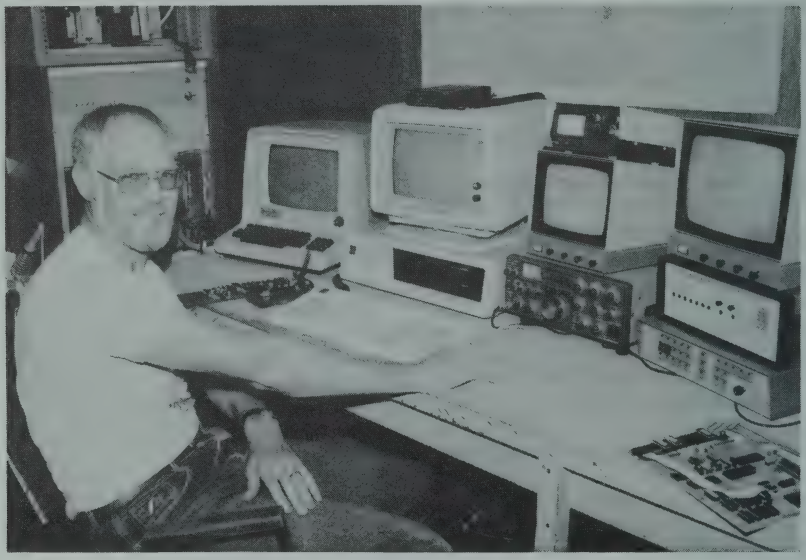


Figure 8-8. VE3DVV's setup involves a top-quality computer and transceiver.

True HF packeting is unique in several respects. Namely, higher RF power levels and higher gain antennas are utilized to cover long distances directly without digipeating, while audio tone shifts are typically 200 Hz rather than 1000 Hz shifts. This narrow frequency swing resulted from early HF packeteers using a readily available supply of Bell 103-type modems for quick and easy HF packeting. Simply connecting that modem between an HF transceiver's mike or earphone jacks and a home computer allowed one to enjoy packet action. The difficulty with using any simple telephone

modem, however, is their lack of selective filtering and poor interference rejection on busy amateur bands. Single tone fades and adjacent channel QRM (man-made interference) are not noted on VHF allocations or telephone lines, but HF is a different matter. The 200 Hz shift gained a foothold, however, so commercial amateur manufacturers began producing high quality modems and TNCs that perform admirably under HF band conditions. We would encourage prospective HF packeteers, then, to use amateur grade/QRM-compatible modems or TNCs rather than simple telephone modems for their operations. There are two reasons for this: it improves your packet communicating success, and it increases on-the-air throughput for everyone. Constant retrys are quite annoying, regardless of the involved parties.

HF packeteers should be aware that commercially manufactured TNCs are normally default/power-up programmed for VHF operations, and several operating commands should be changed for HF operations. Experimenting with TXDELAY, PACLEN and RETRY parameters is highly advisable. As an initial suggestion, notice PACLENS used by others and set yours accordingly while holding RETRY at 2 or 3. Monitor your transmitted signal on an auxiliary receiver, and increase TXDELAY until you're sure a packet's leading bits are not being clipped off by slow TR switching times. The TXDELAY, you'll recall, slows the TNC to match your transceiver's TR switching speed.

As of this book's writing, most HF packet activity centers around 14.103 MHz. Critically accurate frequency tuning is necessary for copying these 200 Hz shift signals, but most HF-compatible TNCs include tuning indicators. The 20-meter/14.103 MHz frequency can be compared with 2-meter and 145.01 MHz activity—it's the "heartbeat" of HF packeting, with nearby frequencies taking the secondary action. HF packeteers should be aware that many VHF/HF interfaced BBSs pass traffic on 14.107 MHz, and general HF packet operations on that frequency should be approached in a conscientious manner. Disrupting such traffic is a good way to get an unpopular packeteer award. Likewise, the North California DX Association's worldwide beacon network operates continuously on 14.100 MHz, and interference with that vital service is taboo. The clever packeteer, however, can use both of these services advantageously. The 14.107 MHz BBS activity is great for tuning in a new HF packet setup or keeping abreast of the news. Monitoring the NCDXA beacon network for ten minutes allows one to evaluate his or her own path to various world areas at that time. There's quite a number of exciting opportunities and capabilities beckoning HF packeteers, but don't just take our word for it—try it yourself.

Summary

As this chapter has pointed out, packet radio's prime attractions are its multiuser activities such as networks and bulletin boards. We must always realize that it's a shared resource, with each user or operator directly affecting a network's usefulness to others. Let's all remember that conscientious cooperation is the keynote to success.

When possible, use direct (nondigipeated) paths when passing messages and notes among nearby friends. If those friends are located in distant areas, consider the utilized digipeaters as a shared resource so everyone can enjoy their benefits. When interlinking through multiple digipeaters, remember to allow sufficient time for relays and enroute collisions before RETRYing the transmission. Naturally, the best way for ensuring that throughput is by holding PACLENS short.

Packet radio is still in its infancy stage, but growing quickly. Consequently the FCC is watching the mode closely to observe its technological achievements, communications benefits and proper use as it relates to amateur radio. The responsibility of correct use—of screening third party traffic and ensuring noncommercial use of packet radio—lies with each packeteer. Act accordingly and conscientiously, and we'll all enjoy packet's benefits for a long time.

Bulletin board systems are an ideal medium for passing messages to friends separated by distance or time. The key to their successful use is following procedures. Do not DX BBSs. That is, always use only the minimum number of digipeaters necessary to reach the nearest BBS. This service should be used when packeteers can't meet on-the-air simultaneously. If their operating times indeed coincide, they can communicate through interlinked digipeaters.

HF packeting and gateway operations are two quite exciting secondary pursuits worthy of investigation. These capabilities extend packet radio's range nationwide and worldwide. Such operations open yet another fascinating aspect of packet action—long-distance communications with briefcase-sized terminals. Additional details supporting these concepts are the subjects of the following chapters.

Packet Radio, OSCAR Satellites, and Electronic Mailboxing

The packet radio revolution is affecting all areas of amateur radio today, and all areas of amateur radio are favorably affecting packet. A good example of this cooperative situation can be found in our continuously expanding OSCAR satellite program. Two amateur satellites supporting UHF packet radio were in daily operation while this book was being written. Another even more exciting satellite is scheduled for a 1987 launch, and several satellites capable of linking the world are slated for launch one or two years thereafter. Additional linear transponders and digipeaters are being planned for the 1990 space station and space shuttle missions. There are even courageous plans to place UHF amateur radio relaying units on the moon.

This migration to amateur communications satellites as well as UHF and low to medium microwave frequencies is indeed the wave of the future. Naturally, time- and frequency-efficient media such as packet radio can play a significant role in that evolution.

As we compare the amateur radio areas of HF and VHF/UHF satellites, some quite obvious differences can be noted. HF communications using any mode from SSB to packet depend on that unpredictable element known as the ionosphere. If a band is open, we can communicate via signals reflected from the ionosphere. If a band is dead, the ionosphere absorbs signals and we can't communicate. On the positive side, our ionosphere doesn't require an expensive launch to put it in place, and it can support the simultaneous reflection of as many signals as there are separate frequencies. Satellites, on the other hand, provide a dependable and predictable medium for simultaneously relaying a large but limited number of signals. Satellites are an active rather than passive medium. That is, they actually process (as well as amplify) their relayed signals. The ionosphere, as a passive medium, can only reflect and attenuate signals. Naturally, the key to successful satellite

use is congenial spectrum and time sharing—something that's quite familiar to all packeteers. Satellites are not a free lunch (or launch). That's where AMSAT comes into the picture.

The Amateur Satellite Corporation (P.O. Box 27, Washington, DC 20044) organizes and plans satellite development, designs, construction, launch into orbit, and performance proofing. After a satellite passes through those many involved and expensive stages, it's turned over to the American Radio Relay League for official administration, and AMSAT diverts its attention back to developing more sophisticated satellites for the future. AMSAT officials worldwide, however, continue serving as vital earth control stations for the orbiting satellite(s). AMSAT is a non-profit organization supported by donations from OSCAR operators and enthusiastic amateurs such as yourself. Assuming they receive our continued support and newsletter subscriptions, the fascinating amateur space program promises to be our most innovative area of expansion. Additional AMSAT information is available from the previously mentioned Washington, DC address. A very informative international AMSAT net is also conducted on 14,282 kHz Sundays between 1845 and 2000 GMT (Greenwich Mean Time). Monitoring this net's bulletins is the most efficient means of staying informed on amateur satellites in use, their orbits, operating schedules, etc.

Overview of OSCAR Satellites

Since today's world of amateur radio includes an unlimited number of special pursuit areas, it's quite understandable that a single individual simply can't stay up to date and informed on all of them. With that in mind, let's briefly review some basic "what they are and how you use them" information on satellites to expand and/or update your knowledge. Some exciting and phenomenal evolutions have favorably affected OSCAR satellites during the last few years . . . but first, let's take a look back.

The OSCAR satellite program received its grand kickoff with the launch of OSCAR 1 during 1961. The small home-constructed satellite orbited the earth approximately two weeks, transmitting its now famous "HI," before its internal batteries died. Two more satellites, OSCAR 2 and OSCAR 3, followed its footsteps (orbits), ultimately proving the benefits and communications possibilities of future amateur satellites. That was Phase I—studying and evaluating the feasibility of amateur radio satellites. Reception reports from around the world were overwhelmingly positive, so Phase III was begun.

Phase II OSCARs were categorized as low-orbiting, sun-synchronous satellites with on-band wideband transponders for simultaneously relaying numerous amateur QSOs/communications. Phase II satellites included OSCARs 4, 5, 6, 7, and 8. OSCAR 9, the University of Surrey's Space Technology Study satellite, could be considered in a separate class of its own. The typical altitude of a Phase II satellite was 600 to 800 miles. The sun-synchronous orbit meant the satellite's position synced to the sun rather than the earth. As the earth rotated on its axis, the satellite tracked a fixed orbit, and amateurs enjoyed long-range signal relays. The 600/800 mile altitude and fast speed as seen from earth limited typical satellite orbit operating time to 20 to 30 minutes every couple of hours each night. "Mode A" (2-meters uplink to satellite; 10-meters downlink/receive from satellite) was the popular mode. A vast number of today's radio amateurs can recall their first amateur satellite communications via OSCAR 6. It was a classic Phase II "bird" with superb mode A performance. Our present Phase III satellites, however, are as revolutionary and advanced compared to Phase II birds as Phase II spacecrafts were to Phase I satellites. Just imagine the upcoming possibilities of Phase IV or Phase V.

Phase III OSCARs are categorized as high altitude and elliptical orbiting satellites, usually with two or more VHF/UHF/microwave wideband transponders for multiple signal relays. Modes supported by these spacecrafts include SSB, packet radio, and CW. One hundred percent duty cycle modes that consume a lot of power such as FM, RTTY, and SSTV are discouraged because a satellite's rechargeable battery and solar cell energy system is a shared resource.

The typical altitude of phase III, elliptical orbit satellites is 11,000 to 30,000 miles, a height permitting direct line-of-sight VHF/UHF/microwave relaying over approximately one-third of the world's area. Figure 9-1 illustrates a convenient means of visualizing elliptical orbits near the equator. A satellite moves far from earth, slows in speed and seems to hover almost stationary for a period, then begins its accelerating trek back toward earth. After a quick zip around the world, it begins the next orbit's journey toward its apogee, the farthest distance from earth. Notice hourly time marks on the orbit in Figure 9-1 and the four to six hours around an apogee while considering the earth's rotation, and you've taken the first step in satellite tracking. The near equator angle of this orbit represents OSCAR 10. Future Phase III satellites are expected to orbit 90° clockwise, reaching an apogee high above the North Pole.

Elliptical orbits are quite unique in nature and a full discussion of how they benefit amateur radio is well beyond the scope of this book. We'll just summarize only the most pertinent information on Phase II satellites and elliptical orbits at this point, and suggest that you check with AMSAT for more details.

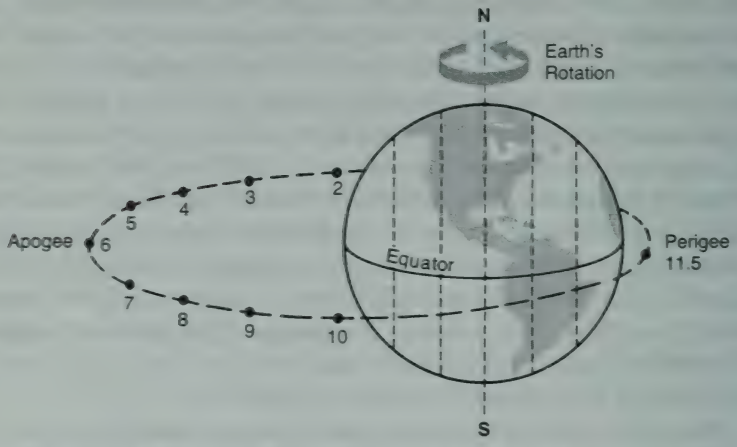


Figure 9-1. Elliptical orbits of Phase III OSCAR satellites.

Elliptical orbiting satellites launched into positions near the equator but not synchronized to the earth (geostationary) seem to move from western to eastern skies over a two- or three-week period. During any particular day, however, the satellite will seem to move only slightly in the sky. This concept is illustrated in Figure 9-2, and it also shows the orbits of our first Phase III satellite, OSCAR 10. Day 1 of a hypothetical 19-day cycle begins when OSCAR orbits the earth and heads toward an apogee 20,000 miles above Hawaii. Long-distance communications capabilities begin as the satellite clears earth and is able to see from Japan and Australia to the United States. Notice the satellite remains in that area favorable to DXing for approximately 6 hours before making its next pass near earth. The following day's orbit progresses easterly at approximately 10° longitude as seen on a world globe, while appearing 40 minutes earlier in time. Four days later, the apogee of the orbit is between Hawaii and Central America. Five days later (day 9 of the cycle), the apogee is over Central America, and 9 days later (day 13 of the cycle) the apogee is between South America and Africa. Five days later (day 18 of the cycle), the apogee is over the far side of Africa. A day's orbits are lost (because they appear on opposite sides of the world), then

the cycle repeats. The intended elliptical orbit for OSCAR 10 would have placed it approximately 90° clockwise, with the apogee over the North Pole. A launch mishap resulted in the equatorial orbit, but the DX results have been fantastic. Upcoming Phase III satellites will be launched into elliptical orbits over the North Pole (we hope . . . riding a giant bottle rocket into space can be tricky). Once again, we encourage all serious OSCAR satellite enthusiasts to check with AMSAT offices and on-the-air nets for the latest and most detailed information on present satellites and their orbits. Using that data isn't difficult, but full discussions are beyond the scope of this book.

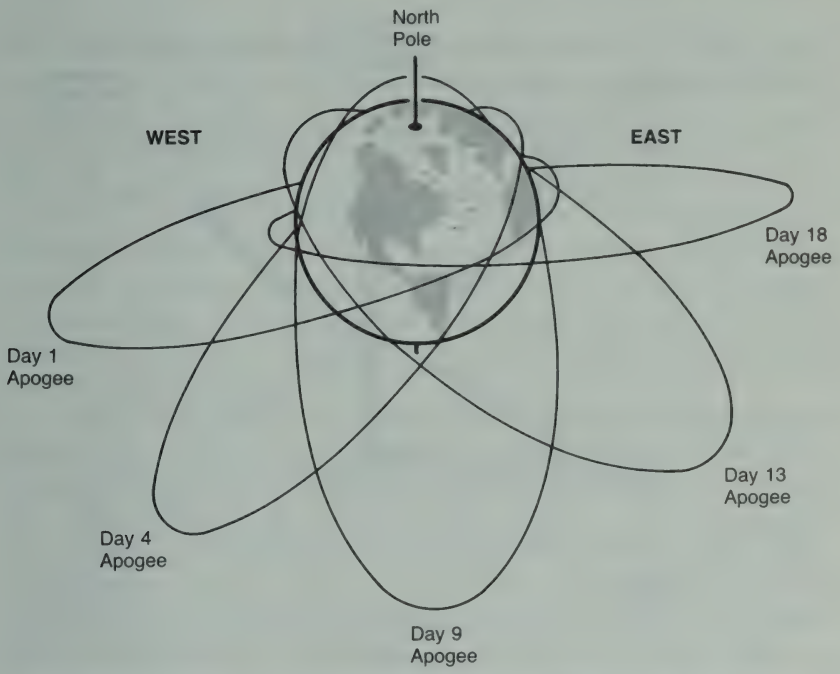


Figure 9-2. Hypothetical view of earth and OSCAR 10 orbits which illustrate the west-to-east satellite progressions over a 19-day cycle.

As previously mentioned, several transponders relaying multiple signals are included on all modern OSCAR satellites. Successfully using these transponders for long-distance communications involves understanding the orbits and tracking of a satellite, knowing which transponder and operating bands are in use at what times, and knowing what frequencies to tune within those bands for a particular activity. Checking with AMSAT is the most

effective and timely means of determining the operating schedule of a particular satellite's transponder. Those operations vary according to seasonal variations, sun angles, and general satellite health. Knowing which frequencies to use for a particular communications activity may vary slightly between satellites, but a universal bandplan has always proven useful with all OSCARs (see Figure 9-3). A transponder's passband can be visualized as three equal segments that are used for CW, SSB, and a mixture of modes. A reference beacon is usually located at the downlink CW section's edge. No satellite-relayed signals should ever be stronger than that beacon.

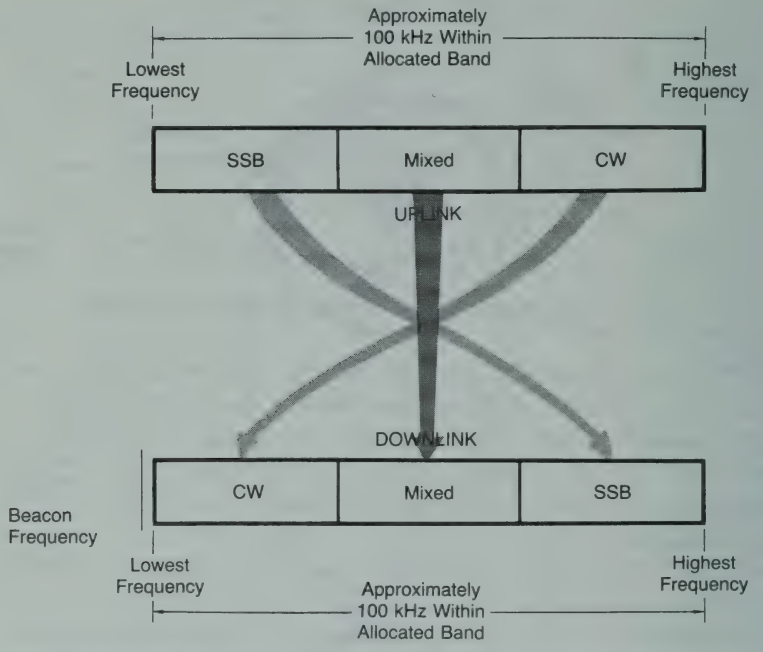


Figure 9-3. The universal bandplan used with all OSCAR satellites.

Any transponder's downlink passband can be mentally broken into three equal bandwidth ranges. The lower third is used for CW, the upper third is used for SSB, and the middle third is used for activities such as packet radio. Since most satellites utilize a frequency inverting arrangement, simply tune your uplink transmitter to the passband's middle, set your downlink receiver to that relayed passband's middle, then slowly "tweak" each rig's frequency until your signals are heard via the satellite. Antenna positions

can then be fine-tuned for maximum signal strength, and output/uplink power can be varied to ensure your signal isn't stronger than the transponder's reference beacon. Progression beyond this beginning point depends on personal interest and incentive to delve further into amateur radio's innovative satellite program. We must add, however, that amateur satellite operations are both fascinating and addictive.

Satellite Equipment Requirements and Interconnections

The most obvious questions among packeteers interested in getting started with satellites typically center around station equipment selections and interconnections. While a full discussion of this area would encompass a small book in itself, we'll present a nutshell overview in this chapter to encourage your pursuit and further involvement in the amateur satellite program.

Today's OSCAR satellites usually include two crossband transponders that operate within VHF/UHF amateur bands, plus a third or "experimentally oriented" transponder designed for operation within the low- to medium-microwave range. Today's popular satellite bands of 2-meters, 70 cm, and 1269 MHz are thus expected to support massive amateur communications for many years hence.

There's an exciting array of multimode transceivers and support equipment advertised in each month's variety of amateur magazines and, almost without exception, they all perform beautifully. The key factors to consider for satellite use include exceptional receiver sensitivity, a good noise blanker and IF shift or passband tuning. The transmitter should include continuously variable RF output and, if SSB operation is also contemplated, an efficient speech processor. The ability to hear your own satellite-relayed signals while transmitting/uplinking is vital to ensure you're getting into the satellite, and to allow for "tweaking" antenna positions, and "zero-beating" specific frequencies. This means your uplink transmitter and downlink receiver will be operating simultaneously. Two transceivers, each with its own power supply, are usually employed for such full duplex operations.

We advise you use a high quality and low noise GaAsFET preamp for copying weak satellite-relayed signals. A transceiver lacking GaAsFET preamp benefits typically yields S-1 apogee copy of elliptical orbit satellites, while an external GaAsFET preamp boosts those levels to S-7 or S-8 without increasing background noise. A superb receiving setup, incidentally, is much

more desirable than a strong transmitted signal. The GaAsFET preamp should be RF-protected, as many modern transceivers cycle through transmit when turned on.

Approximately 100 watts of transmitted RF energy is suggested for reliably accessing Phase II, circular orbit satellites, and 1000 watts is suggested for Phase III birds. Note these figures are effective radiated power (ERP), and reflect antenna gain. A 100-watt output transmitter feeding a unity-gain turnstile antenna with a short length of low-loss cable provides 90 watts ERP. A 50-watt transmitter feeding an approximate 14 dB gain Yagi through a 1.5 dB loss-length of coax cable yields approximately 1000 watts ERP. Assuming the transmitter's RF output is continuously adjustable, maintaining a communications-quality signal into a satellite without overloading its transponder is a cinch. No one's relayed signals should ever be stronger than a satellite's reference beacon signal.

A typical OSCAR satellite setup and interconnections are shown in Figure 9-4. Two transceivers are shown—one for uplinking and one for downlinking. Exactly which one is employed for which function depends on the transponder used at a particular time. OSCAR mode B uses the 435 MHz band as uplink and the 145 MHz band as downlink, for example, while mode J utilizes a small section of the 145 MHz band for uplinking and a similar portion of the 435 MHz band for downlinking. The upcoming mode L uses 435 MHz for uplinking and 1269 MHz for downlinking. With that understood, it's obvious that Figure 9-4 demonstrates mode B-type operation. This example utilizes Icom's popular IC-271H and 471H transceivers, each equipped with optional AC supplies to diversify current demands and avoid crosstalk (one rig "getting into" the other rig). Likewise, RF desensitization of the receiving unit (2-meter/271H in our example) is minimized by using a 6- to 10-foot nonmetallic crossboom. The length of that crossboom isn't critical; it only serves to hold and separate the satellite's antennas (and, yes, it can be longer than 6 feet if you have the space). A third antenna such as a 1269 MHz Loop Yagi may be mounted near the crossboom's middle if desired. The illustrated setup depicts Phase III OSCAR action, as its included 20-element antennas produce approximately 1000 watts ERP. The beauty of the antenna in our "AOP-1 Package" is its ease of purchase and assembly without having to hunt for those few elusive pieces which always seems to happen when you're rigging your own antenna package. Smaller antennas, such as the JO-12, could be used for Phase II orbiting satellites, but high-gain, Phase III capabilities would be sacrificed. Reducing transmitter output to 5 or 10 watts and retaining high-gain antennas provides both Phase II and Phase III capabilities.

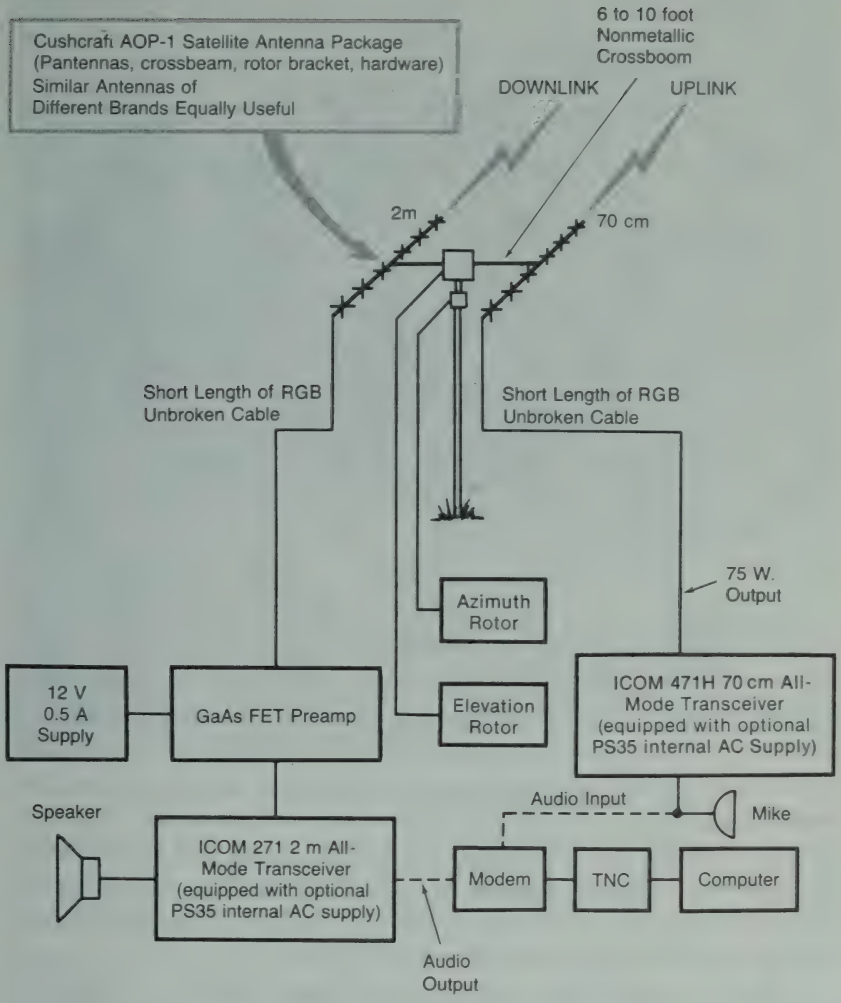


Figure 9-4. Typical OSCAR satellite layout and interconnection arrangement.

Notice the receive/downlink transceiver is complemented with a high-gain, low-noise GaAsFET preamp. These units are small and conventional-looking (see Figure 9-5), but their performance is truly remarkable. Conventional bipolar or FET preamps increase both signal(s) and noise (so what's the gain?), whereas GaAsFETs increase only the signal(s).

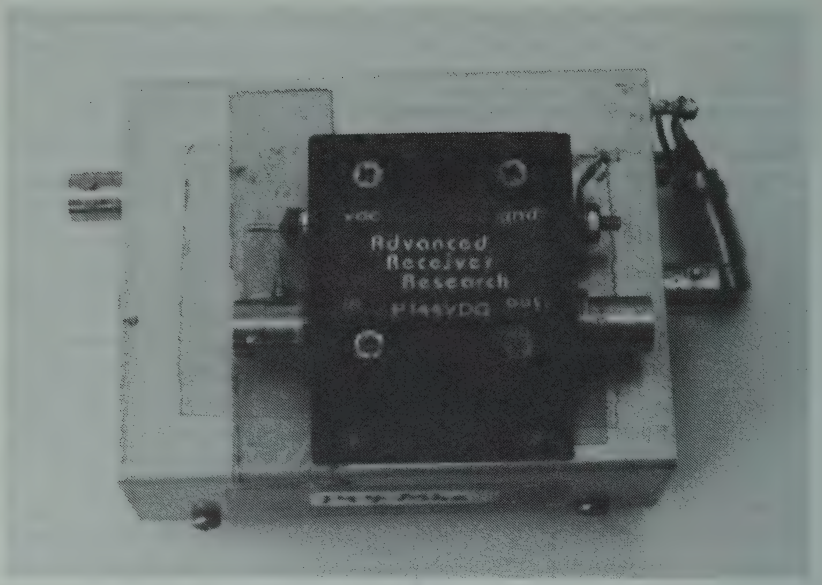


Figure 9-5. A GaAsFET preamp.

Always strive to install an OSCAR setup and its associated antenna system so that no more than 20 feet of cable are necessary for interconnection. Even 20 feet is many wavelengths at 435 MHz—attenuation comparable to connecting a half-mile of coax to your Triband HF beam. If you're trying OSCAR satellites for the first time or you're more attuned to packeting than station engineering, avoid hardline coax with its oddball fittings. Likewise, install the sensitive GaAsFET preamp in the shack rather than at the antenna. It's out of the weather then and can be totally removed during thunderstorms. Needless to say, only new and top-quality foam-filled RG-8 cable should be used and all connections should be waterproofed.

The setup's two rotors control north and south (azimuth) positioning and the degrees of skyward tilt (elevation) of the antennas. Both parameters are necessary because of angular variations in a satellite's orbits. There's also a significant difference between the skyward positions of Phase II- and Phase III-type satellites.

What does a typical OSCAR setup look like after assembly? That's a very good question, since there are nearly a hundred different variations of gear and antennas! The author's home OSCAR packet setup shown in Figure 9-6 consists of several "double duty" units. A popular and inexpensive

Ten Tec 2510 "satellite station" unit (top left) is used in conjunction with an ICOM-730 HF transceiver (behind C-64 keyboard), Mirage D-1010 100-watt output RF amplifier, and an external GaAsFET preamp. The Ten Tec 2510 includes a 2-meter to 10-meter converter plus a 10-watt 70-cm transmitter in its cabinet. The ICOM-730 completes the "receive" side, while its AC supply also powers the 70-cm amplifier. The Ten Tec unit and GaAsFET preamp are powered from separate supplies.

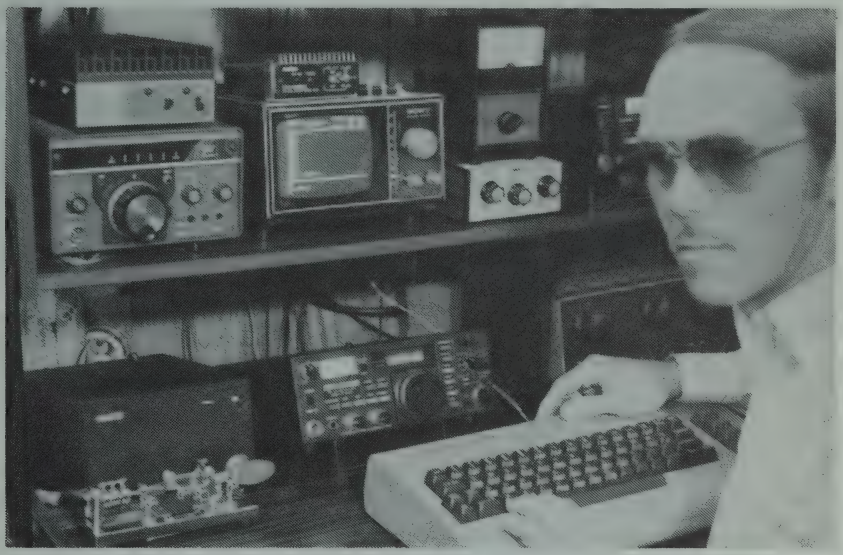


Figure 9-6. The author's home OSCAR/packet setup.

Outside and approximately 12 feet away, separately acquired antennas are mounted on a plastic pipe crossboom for satellite operation (see Figure 9-7). It consists of a 70-cm cross Yagi (the small antenna with a weather-proof bag over the phasing unit) and a 2-meter cross Yagi (the larger antenna). The crossboom is plastic pipe to avoid crosstalk. A triband HF beam is also visible in the background. Notice their transmission lines droop at different angles to avoid crosstalk/desensitization. Notice in this photo (taken early in Phase III and before updating) that an elevation rotor is missing. Although we previously suggested following that easier route, we learned to use two rotors and a complete antenna package for maximum efficiency. Of course, when you're in a hurry and it's winter and cold outside . . .

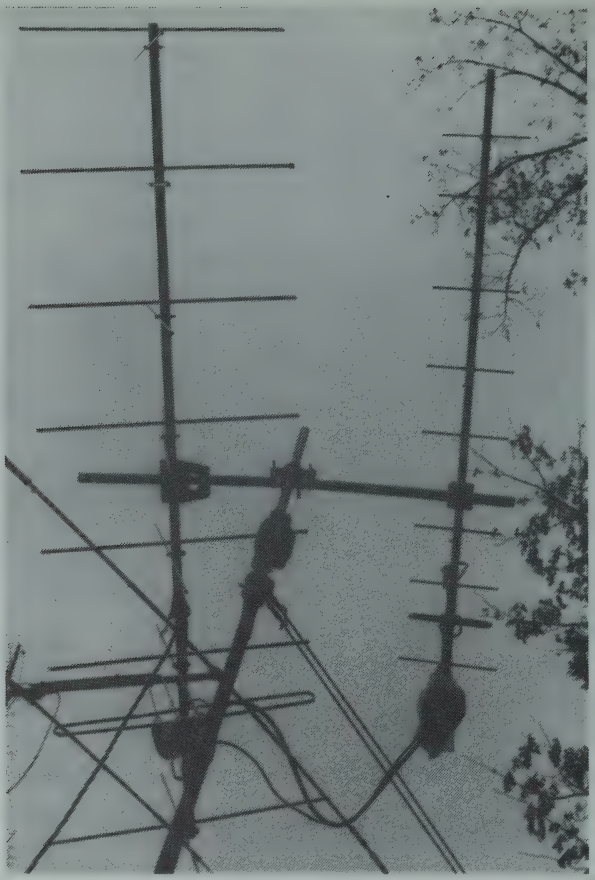


Figure 9-7. The author's OSCAR satellite antenna system.

Portable OSCAR/packet activity is another very popular pursuit that definitely warrants investigation, especially for flying mailbox type applications. Low-orbiting satellites such as JO-12 can be accessed using relatively small antennas placed on a modified camera tripod and connected to portable, battery-powered transceivers. The basic equipment required can be carried in one briefcase (see Figure 9-8), and a second briefcase can carry the packet radio's computer and TNC, making the setup extremely flexible and efficient. Our "James Bond" packeteer could click together the pieces and uplink messages to a mailbox encircling the world, travel to another location and retrieve reply mail in style. That's packeteering the modern way.

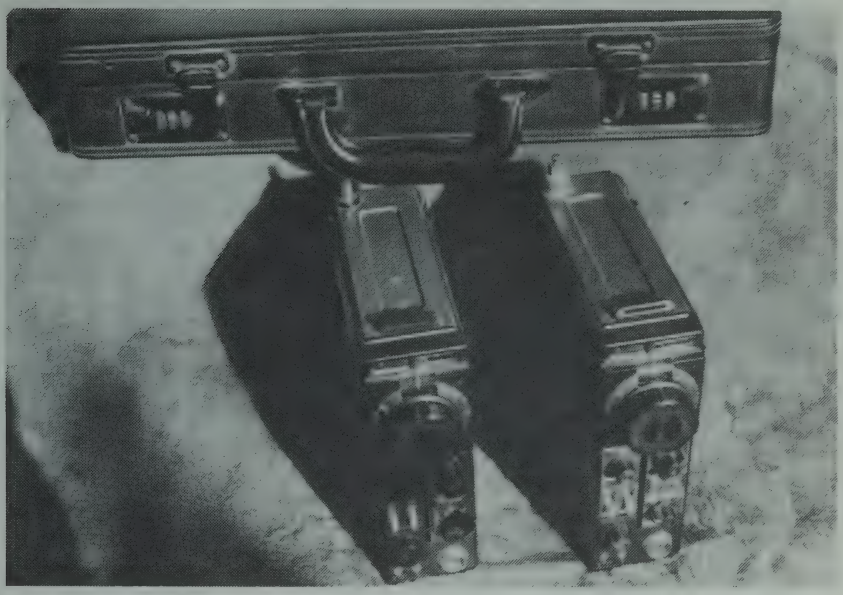


Figure 9-8. The basic items for assembling a briefcase-size portable OSCAR satellite setup.

Communicating and Packeting Via Satellite

There are presently two interesting styles of amateur satellite utilization and communication: using Phase II orbiting crafts such as JO-12 and/or using Phase III orbiting birds such as OSCAR 10 (and its upcoming successors). Using Phase II-type satellites is especially attractive for dedicated packet operation because equipment requirements are basic, and station assembly is easy. A typical horizon-to-horizon pass takes just 15 to 20 minutes, but not more than a couple of minutes are needed for sending and retrieving packets from this flying mailbox. Phase III-type satellites are also useful for both packet and voice operations, and they might be pictured as super long-distance relay units that directly see one-third of the world at any time, and that time can extend up to 6 full hours each day. A more sophisticated and fixed-station setup is necessary for accessing Phase III-type satellites, but their real-time globe-spanning capabilities are definitely worth the effort. Either way you consider going, here are some helpful operating notes.

The capability of copying one's own downlinked signals while transmitting to a satellite serves two important purposes. It permits direct signal strength referencing to a transponder's beacon (no one's signal should ever be stronger than the beacon, as that usurps satellite power and limits weaker users), and it prevents QRM. There's no skip zone on satellites—everyone hears equally, and leaving elbow room is a necessary courtesy. The most logical means of getting the feel of these operations is tuning in and monitoring satellite activities for a few days before joining that action with your transmitter. Keep in mind that most satellite transponders include an inverting passband. As a beginning point, set your transmitter and receiver to the respective satellite transponder's passband middle. Point your antennas toward the satellite, then tune your receiver slightly to compensate for Doppler shifts, and locate your downlink signal. Moving into full operation after that point, remember that for each kHz your receiver is tuned above the transponder center, it's the same as tuning your transmitter an equal number of kHz below its transponder center for frequency tracking. Today's digital dials make these moves a cinch, and computer interfacing is also helpful.

If you monitor a satellite's operating frequencies for several days without noticing any action, check with the AMSAT nets mentioned previously in this chapter. There's a good possibility you're doing everything right, but the transponder's operating schedule isn't coinciding with your on-the-air times. Packet radio and OSCAR satellite operations go hand in hand with each other. Simply remember to share the resource while operating via satellite, and you'll be a welcomed packeteer.

Fuji JO-12: Packet's Flying Mailbox

The August, 1986 launch of Japan's first amateur satellite, JAS-1, initiated an exciting new era of space communications for packet radio enthusiasts. This compact spacecraft boasts design concepts and communications capabilities that are quite unique in several ways. It employs a 100 kHz-wide linear transponder/broadband repeater plus a four-channel input and one-channel output digital/packet mailbox, and the satellite is placed in a low Phase II-type orbit. A prelaunch photo and sketch of this satellite are shown in Figures 9-9 and 9-10.

Following an absolutely flawless launch into sun-synchronous and circular orbit approximately 700 miles above earth, the satellite was honorably renamed Fuji OSCAR 12, or simply JO-12. Its predicted lifespan is

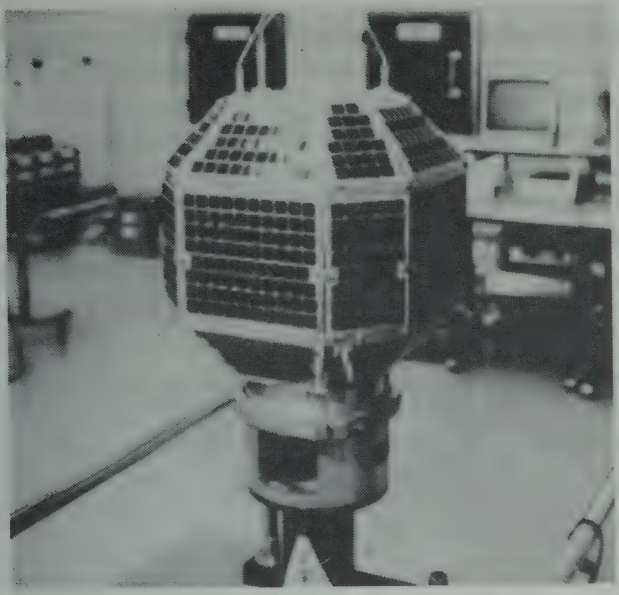


Figure 9-9. Prelaunch view of the JAS-1 satellite with packet radio capabilities.

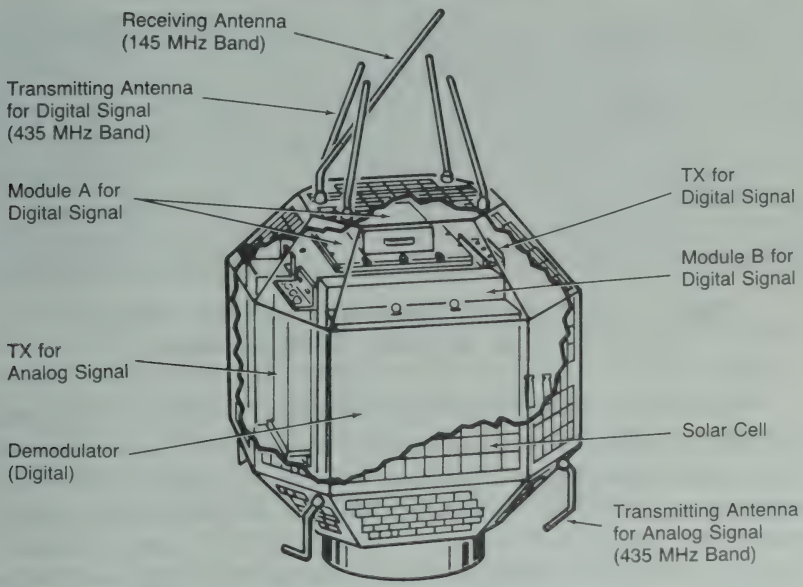


Figure 9-10. Sketch of JO-12, illustrating general packaging and antenna layout.

three to four years, and present indications promise a healthy and rewarding future for the spacecraft. It boasts 1.5 megabytes of digital data storage area—that's a lot of packets.

JO-12 uplinks signals in the 2-meter band and downlinks signals in the 70-cm band. Specific frequency ranges are allocated for SSB/CW mixed modes and packet radio signals as shown in Figures 9-11 and 9-12. The mode J linear transponder's center frequency is 145.950 with a lower limit at 145.900 MHz and an upper limit at 146.000 MHz. The conventional bottom third for CW, middle third for mixed modes, and upper third for SSB bandplan has been adopted.

Uplink passband:	145.950 MHz—146.00 MHz (LSB)
Downlink passband::	435.80 MHz—435.90 MHz (USB)
Beacon frequency:	435.795 MHz
Translate frequency:	581.80 MHz
Transponder output:	1 Watt PEP
Required uplink power:	100 Watts eirp

Figure 9-11. Uplink and downlink passbands used with JO-12's linear transponder.

Uplink channel 1:	145.850 MHz
Uplink channel 2:	145.870 MHz
Uplink channel 3:	145.890 MHz
Uplink channel 4:	145.910 MHz
Uplink data format:	Manchester-coded FM, 1200 baud, AX.25
Downlink channel:	435.910 MHz
Downlink data format:	PSK, 1200 baud, AX.25
Downlink power:	1 Watt rms
Required uplink power:	100 Watss eirp

Figure 9-12. Frequency allocations and operating parameters for JO-12's mode JD packet radio flying mailbox.

The satellite's mode JD, or digital/packet store-and-forward system includes four uplink channels and one downlink channel. This arrangement of more inputs than outputs increases overall user efficiency. Packet's conventional AX.25 version 2 protocol is used for maximum ground station compatibility and general use of TAPR-type TNC 2 clones; however, Manchester-coded FM uplink and PSK (phase shift keying) downlink are employed in lieu of packet's usual FSK. These changes provided the most efficient use of satellite resources while allowing the closest possible match

to presently used TNCs. Adapting an existing TNC to these parameters for packet radio operation with JO-12 involves disconnecting the TNC's internal modem chip(s) and connecting an external Manchester/PSK 1200 baud modem. As this book is being written, TAPR is working on the final stages of modem production. It will probably be available (from TAPR or its licensed clone manufacturers, such as AEA, MFJ, Kantronics, etc.) by the time you read this book. Meanwhile, check your TNC to ensure its HDLC can be connected to an external modem.

The output of the JO-12-compatible modem then connects to a 2-meter FM transmitter in the same manner as any packet radio setup; however, a 70-cm SSB receiver is necessary for copying JO-12's downlink signals. These capabilities point out the importance of all-mode transceivers for VHF and UHF amateur bands. As we've stated previously, migration to higher and higher frequency amateur bands is simply the wave of the future.

JO-12's altitude and circular orbit makes it a fast moving satellite with approximately twelve earth orbits a day. Usually, only two or three orbits are within line-of-sight range of any particular earth-based station. Likewise, the typical horizon-to-horizon time of a pass is 15 to 20 minutes. This doesn't provide much time for casual armchair SSB QSOs, but it's great for modern packeting. You uplink packets addressed to other packeteers in far-off lands, the satellite passes over many of those areas an hour later, then returns with your reply an hour afterwards. If some packets are addressed to amateurs outside of the previous orbit's range, they're retained in the mailbox until many orbits later when the earth's rotation moves those areas into JO-12's range. In this case, you uplink packets one night and receive reply packets the next night. In other words, JO-12 is indeed a true flying mailbox.

Tracking JO-12's orbits is a relatively simple matter, but newcomers will need some items to assist them such as an older OSCARLocator or computer tracking program. Either of these items can be obtained from the AMSAT offices at P.O. Box 27, Washington, D.C. 20044. Armed with that information, plus any orbital updates and schedules of JO-12's transponder operating times, your're set to enjoy the ultimate experience in modern packeteering.

Future Packet-Attractive Satellites

As we take a look down the road ahead, we see some fascinating times in packet radio's space communication future. During late-1987 to early-1988, for example, our next Phase III satellite is scheduled for launch into elliptical

orbit over the North Pole. From its 20,000-mile apogee point, it will see roughly three-fourths of the active amateur radio world, from Japan through Central America to all of Europe and most of Asia. In addition to its linear transponders, the satellite will carry a packet radio setup/digipeater known as RUDAK (Regenerative Umsetzer fuer Digitale Amateur Kommunikation, a German-built unit). This unit will act as a true digipeater with phenomenal range, plus it will be able to easily pass along important bulletins and news to world amateurs.

As of late-1986, the RUDAK unit had been built and ground tested under actual packet digipeating conditions. It worked beautifully—like a dream digipeater. The unit was then shipped to the Phase III construction site for integration into our next OSCAR. The amateur community and AMSAT must now wait in line for the U.S. space program to get back on its feet and move forward. We're all too familiar with the January 28, 1986 tragedy that claimed the lives of seven magnificent pioneers and threw our space program into dark depression.

RUDAK will be a true digipeater with an uplink input on 1269.675 MHz ± 7.5 kHz, and a downlink output on 435.675 MHz. Input data speed will be 1200 and/or 2400 baud PSK, and output data speed will be 400 baud PSK with a 1200 baud option. The AX.25 version 2 protocol will be used. Since JO-12 will still be functioning as a flying mailbox, store-and-forward packeting isn't planned for RUDAK. As with JO-12, a similar add-on/external modem connected between a TNC and 1269/435 MHz transceivers will prove to be the equipment of the day. 12 watts of RF to a 15 dB 1269 MHz antenna should be adequate for transmitting, and a 10-dB gain 435 MHz antenna connected to a 5- or 8-dB gain GaAsFET preamp and modern receiver should be ideal for receiving. Watch the monthly amateur magazines and AMSAT reports for more details on Phase III and RUDAK as they evolve.

Looking further down the yellow brick road ahead, we see plans developing for a triple launch of three geostationary amateur satellites. This Phase IV concept will provide true real-time global communications, and packet radio is expected to be a natural part of its capabilities. Due to its complexity, the full Phase IV story is contained in an upcoming chapter of this book.

Plans and design ideas for moon and space station transponders and digipeaters are occasionally being heard at AMSAT meetings and on net discussions at this time. Using past events as a reference, we've seen most (even all) of those ideas eventually become reality. Reading the writing on the wall, so to speak, it's obvious those plans will become reality . . .

probably within the next decade. Low microwave frequency amateur bands will surely be the order of the day as that new version of our Golden Age of Radio—modern style—becomes a way of life. Today is grand, but tomorrow really looks great!

Summary

OSCAR satellites are playing a significant role in packet and amateur radio today, and their future evolutions seem truly unlimited. The use of UHF and low microwave bands for satellite communications also indicates our path of future migrations toward an ionospheric-independent medium that's both predictable and reliable. The really impressive part of this modern form of communications is its availability to all packeteers and radio amateurs holding a Technician or higher class license . . . right now! There's never been a more opportune and exciting time to get in on the ground floor of a fascinating new technology!

December, 1986 marked the 25th anniversary of our OSCAR satellite program, a dream that began with a simple homebrewed 2-meter transmitter getting a piggyback ride into space during 1961. We're now into the third generation of OSCARs, and their leading edge technology continues in high style by supporting new areas such as packet radio communications.

Adding OSCAR capabilities to an existing amateur setup typically involves installing relatively small antennas with short feedlines, adding multimode transceivers for desired bands, and learning simple satellite trackings. The guiding light for satellite information has always been, and will continue to be, AMSAT of P.O. Box 27, Washington, D.C. 20044. The close association of AMSAT, OSCAR, and the world of packet radio is also reflected in the many local and national packet BBSs continuously carrying all the latest OSCAR news and tracking details.

We must all remember that OSCAR satellites are a shared resource, and congenial sharing of their benefits is vital to the continued success of the program. SSB and CW operators must recognize and respect that fact by always holding their signal strength below that of a transponder's beacon and ensuring their signal isn't disrupting other satellite QSOs. Packet radio enthusiasts are encouraged to monitor AMSAT nets and BBSs for the operating guidelines of the day. Sometimes HF-type (person-to-person) packet QSOs within a transponder's mixed modes range are allowable—sometimes they're not. Sometimes individuals can use a satellite's digipeating

functions directly—sometimes they're reserved for packet network gateways. These factors change according to satellite conditions and packet radio's activity and popularity. Any way we look at the situation, however, the combination of OSCAR satellites and packet radio is an exciting mix of new technology guaranteed to rekindle one's original enthusiasm and appreciation for amateur radio. It's a great pursuit, and it's bringing the future to us today!

Packet Portable: It Goes Where You Go

As most amateurs will surely agree, our modern lifestyles tend to be quite mobile. Whether pursuing business or pleasure activities, we're continuously involved in situations away from the home that seemingly restrict our amateur radio activities. Likewise, few emergency or public service activities requiring our assistance can be effectively handled with everyone at his home station. Some of us must travel to the site of that activity. Those situations underscore the need for, and the widespread popularity of, small VHF handheld transceivers and compact mobile units. They can go anywhere we go and provide immediate voice communications and that necessary link with the outside world. Voice communications may not be the fastest way to move vast amounts of information in the shortest possible time, but transporting a full-blown RTTY setup isn't always practical. Enter the flexible capabilities of portable packet radio: a full 400-plus words-per-minute system complete with lap computer, pocket-size TNC, and VHF talkie plus battery packs that fit smoothly in a standard-size briefcase. Replace the talkie's rubber ducky whip with a small clamp-on outdoor antenna, and we're set to pass a great amount of information in a truly efficient and professional manner. In addition, with a hardcopy printout from a lap computer, an operator can avoid misunderstandings and confused copy in noisy environments.

Looking closer at emergency or public service applications, the ability for any packet setup to also function as a digipeater is particularly attractive. A half-dozen portable systems can be set up as needed almost anywhere to form an instant network. The possibilities are endless. Bicycle races, floods, or forest fires are only three examples that require a network with communications from different locations.

On the pleasure side of portable packet, a briefcase style setup holds special merit for many applications. If your lifestyle involves a lot of traveling,

moving through airports, and spending nights in motel rooms, a briefcase packet system puts you in touch with area networks in a genuine "James Bond" manner. Merely clip an antenna onto a window frame, interconnect a talkie and TNC, slip a portable computer such as Radio Shack's model 100 onto your lap, and join the action. If you're not thousands of miles from home, you can probably multilink back to friends for news and information exchanges. Meeting and greeting new friends in the visited area also has its rewards. If you're away from your hotel or motel room until the late hours when packet radio activity is quiet, you can still enjoy its many BBS and E-Mail attractions. Who knows . . . exchanging those friendly pieces of amateur radio related mail may make an otherwise boring venture one of sheer pleasure. You might even decide to use the briefcase setup as your exclusive packet system both at home and on the road. The idea could indeed work almost anywhere (although hardcopies in a sauna would be a mite soggy).

This portable packet system could also be expanded in a quite interesting and modern way by adding OSCAR satellite capabilities in a second standard-size briefcase or travel bag. The first and most obvious benefit of this arrangement would be the ability to use JO-12's flying mailbox described in the previous chapter. Visualize the concept: 10 minutes before an in-range satellite pass, you click together a couple of breakdown four-foot antennas and connect them to two portable transceivers (your 2-meter/VHF FM talkie can also be used for satellite uplinking, and a 70-cm SSB portable can be used for downlinking). You then put the packet system's lap computer into use, send and retrieve mail via JO-12, and disassemble the system 20 minutes later to wait until it's needed for the next day's mail returns.

Portable packet is a very versatile pursuit with many attractive benefits, and this chapter will take a detailed look in that direction. We'll discuss setting up a briefcase packet and OSCAR station, survey portable equipment, and even add some notes on a downsized pocket packet setup for strictly light travelers.

The Portable Message Drop

Although the initial idea of a portable message drop might seem more like a novelty than a necessity, it's definitely proving its value in today's fast-paced world. The general facts backing up that statement are all too familiar—we're spending an increasing amount of time away from home

pursuing our vocation, improving our education, etc. That doesn't mean we have to give up amateur radio activities, however. A slight alteration in operating style can still keep us informed and in the mainstream of action.

Using a portable packet system while on the move, we can leave and retrieve messages with similarly busy friends in a sort of quasi-QSO manner. The common storage medium for those continuously changing notes might be a local BBS or packet mailbox, your own (separately operating) home packet setup, or the portable packet system itself if it can store BUDLIST messages for unattended operation. You leave a message at your convenience, close your portable packet setup and continue with other activities while your friends do likewise. Later, and probably at a different location, you reopen your portable packet setup and review exchanged information. QSOs may even be more productive using this arrangement, as it leaves ample time for thinking between times of commenting.

The large number of husband and wife amateur radio families today may easily find portable packet systems more appealing than cellular telephones. We've all played the familiar game of phone tag in which the other person seems to always be away from the phone when needed. Using the portable message drop concept, however, those same amateur family members can coordinate efforts and plans in an unbelievably efficient manner. No more forgotten stops or missed lunch appointments. The portable system and lap computer keep you right up to date with all activities. If one family member is home when the other is away, only one portable setup is necessary. The home's packet system can be left on with a selected BUDLIST for keeping track of messages. The inspirations are unlimited, but exactly how do you fit a full packet system into a small business size briefcase? That's the fun part, and it may be easier than you think.

Packet in a Briefcase

The main ingredients in any packet radio setup are a VHF transceiver and its mating antenna, a TNC, and a home or personal computer with supporting communications terminal software. Since exceptionally small battery-powered versions of those items are presently quite popular, fitting a full setup into a briefcase is relatively easy. The portable system in Figure 10-1 shows how various items fit comfortably into a briefcase. Straps with adhesive backs hold talkie, TNC, and battery packs. Notice the added antenna socket in lid. Briefcase packet systems are also great for mobiling provided you're

not the driver. Glen Popiel, WA4FTX, and Chet Lambert, W4WDR (driver, not in view), show us the technique in Figure 10-2. The system consists of RS-100 computer, GLB TNC, and ICOM talkie.

The key factor in assembling a briefcase system involves using a portable computer that includes batteries, a built-in terminal program, and full RS-232 compatibility. Radio Shack's popular 100 and 200 series computers fill those requirements quite comfortably, and IBM's new convertible/portable computer promises to be stiff competition. Both handheld and ultra compact high-power VHF transceivers have proven their merit in packet operations, and nearly any small TNC will fit in a briefcase with a VHF rig. The problem

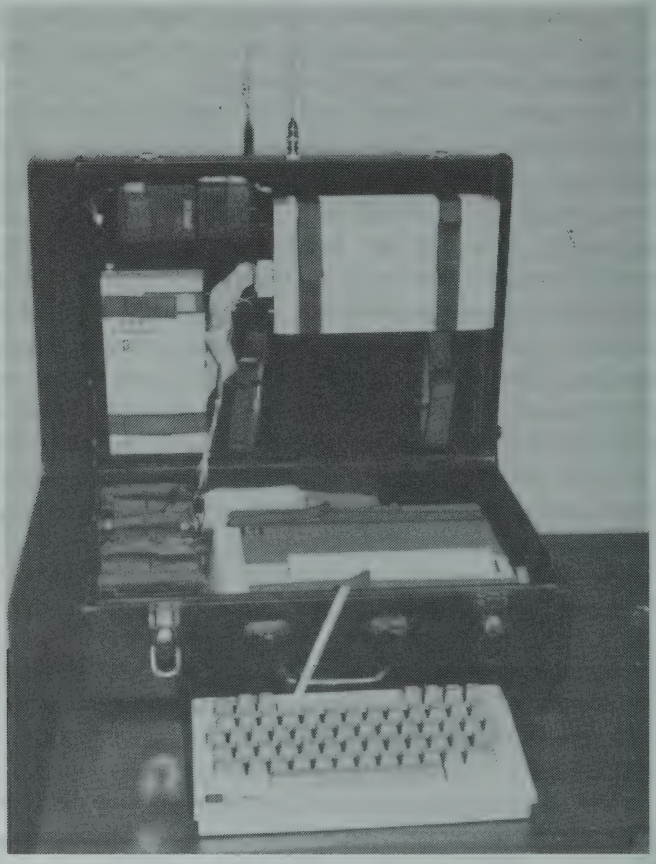


Figure 10-1. WB4GQX's portable system.

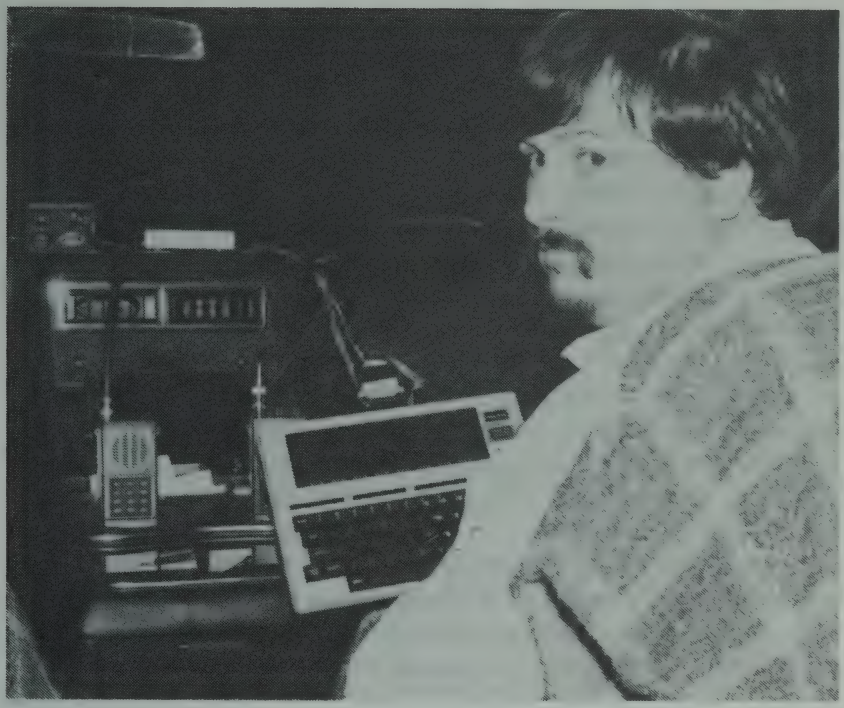


Figure 10-2. A briefcase packet system in mobile operation.

appears only when we add a couple of patch cords, external batteries for the TNC, and a small antenna, and then try to close the case. The computer or the TNC needs to be a couple of inches shorter, the antenna needs to fold in half, and protective padding is needed between each item. Fortunately, each of those requirements is easily satisfied. First, however, let's interconnect the portable system and check its performance before outfitting and sectionalizing the briefcase.

Interconnect the planned portable packet system using the exact patch cords you'll use in the completed version to ensure smooth future operation. Don't rush this step. Use the system at home a couple of days to recognize any weak points or uncomfortable shortcomings. If you have a couple of different VHF transceivers, try both of them in case a swap is necessary later. This is also the ideal time to standardize all connectors and cable

adapters for later field flexibility. There's nothing more heartbreaking than having a superb packet system sitting idle at an emergency site because of incompatible connectors with an auxiliary TNC pressed into service at the last minute, or a loaner VHF transceiver. Plan ahead. Including a few extra clip leads (and maybe a microphone/TNC interconnection sheet for the units currently popular), plus a spare cable set are also worthwhile considerations. A simple yet effective rollup antenna such as the homebrew unit described in Chapter 5 is another handy item when something more than an ordinary rubber ducky whip is desired. Remember . . . it's always better to have it and not need it than to need it and not have it. Satisfied with the portable rig's layout and operation? Let's move ahead.

Lay out your portable items and visualize how they fit in the briefcase. Remember to keep fragile or sensitive items toward the top/handle to avoid undue stress. A small TNC is usually required for briefcase comfort. If your TNC is too large or requires a large battery, consider replacing it with GLB's miniature PK1-L described later in this chapter. The tiny unit can be powered by an ordinary 9-volt battery, and is RS-232 compatible . . . a double space saver. Handheld transceivers have been proven to perform exceptionally well in packet radio service, and they are also a double space saver. That is, they're extremely compact and they include their own batteries. Since various units include different means of keying their push-to-talk lines via remote mike inputs, we suggest checking with the specific manufacturer regarding their hookup. Usually, the incoming audio line must be isolated from the mike's hot wire and ground. The resultant setup—computer, miniature TNC, and handheld transceiver—should fit in the briefcase with room left over for compartment separators, cables, etc.

Lining the briefcase with light foam or felt obtained at a cloth supplier is an obvious first step. Crazy glue holds both lining and separators in place quite comfortably. Likewise, Velcro backed straps and compartment doors are dandy for securing everything quite snugly while providing immediate access. If you need more creative ideas on briefcase layouts, look over some of the professional tool kits displayed at electronic parts stores, sketch their ideas, and adapt them to your own needs. As all radio amateurs know, home assembly is the logical alternative when a particular item isn't available commercially. Likewise, you can always write a magazine article on your finished product and share your creativity with others. Who knows . . . you might inspire a new trend or modern craze. Ready to go into full scale production?

Adding OSCAR Satellite Operation

As discussed in the previous chapter, adding satellite capabilities to one's packet radio setup is a relatively simple and quite rewarding maneuver. The idea we're outlining in this chapter, however, is a dedicated portable or "bush" type setup that can be used in stand-alone form for voice communications or interfaced with a briefcase packet system as desired. The concept of a downsized satellite system is thus attractive for its size, weight, cost, and flexible use. I've personally assembled two such setups and, quite frankly, I think they're ideal in a hundred different ways. Home QTHs are often plagued with trees and foliage that absorb VHF and UHF energy like a sponge. Complete outdoor setups can be placed in clearings for brief satellite pass operations. Portable operations via satellite are also unique. Don't just take our word for it. Try it and see for yourself.

At least two manufacturers have produced small lightweight VHF and UHF transceivers that fit smoothly into a briefcase or even an over-the-shoulder camera bag. Icom's early Model 202 (2-meters) and 402 (70-cm) SSB transceivers include internal batteries, and these units continue surfacing in both new and used forms at various hamfests. The same is true of KLM's Echo VHF and UHF transceivers, but those units require an external battery pack. The most convenient (quickest to implement) packing arrangement I've found is using Velcro fasteners to hold a small RF amplifier onto one unit's side, using a cardboard spacer between the transceivers, and stuffing them with the knobs up into a 35-mm camera bag. Two section antennas and a simple mount are then stuffed into another bag and carried in the auto's trunk. My "click together" 70-cm antenna is shown in Figure 10-3. The full setup goes from package to communication in less than 10 minutes. Its 15-dB gain provides superb satellite reception using only a handheld transceiver. A small 2-meter beam antenna and a support mast complete the "bush" setup.

When planning and assembling a portable satellite system for packet use, bear in mind you also need orbital predictions and transponder schedules. A book of yearly orbital data is available for ten dollars from Project OSCAR, Inc., P.O. Box 1136, Los Altos, California 94023. Transponder operating schedules tend to change every couple of months, so check with the AMSAT nets mentioned in the previous chapter for the latest developments.

Finally, assemble the whole portable setup so that only 10 or 15 feet of coax cable is necessary for antenna and rig interconnection. This might

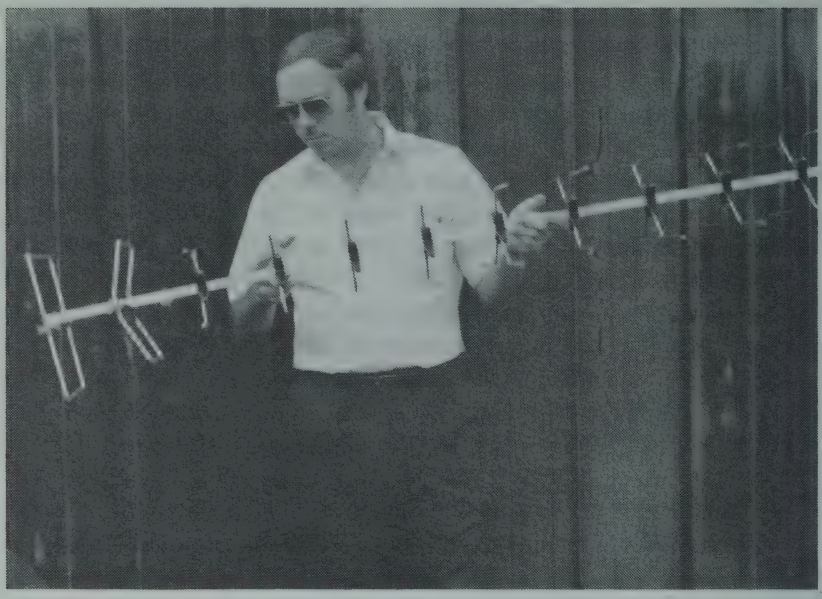


Figure 10-3. Author K4TWJ's click together 70-cm portable satellite antenna.

call for moving the portable packet system into an unusual place for its brief operations, but the resulting and interrelated benefits are worth the effort. You'll be close enough to the antennas and receiver to simply reposition the antennas by hand while monitoring reception (Armstrong tracking), and RF losses will be minimized. You'll also have all the equipment in one place for quick and easy disassembly after use, and you can always move to quieter locations if power line noises become troublesome. Portable packet and low-orbiting Phase II/JO-12 satellite operations are a fascinating modern-day pursuit. Give them a try soon. You'll love it.

Pocket Packet

Wouldn't it be grand if you could carry a complete packet radio system in your vest coat pocket or clipped onto your belt? You could pull out a computer the size of a calculator with a miniature keyboard (and maybe a direct voice interface), plug it into your wrist 2-meter transceiver, and check the local

mailbox from any convenient location. Gateway operations could extend that range almost worldwide. Fantasyland? Not necessarily. We've already heard casual rumors of such micro-talkies being considered by foreign manufacturers, and many of us remember a few years ago when talkies the size of cigarette packs seemed impossible. A couple of years ago, Radio Shack produced a limited capability pocket computer with BASIC programming. If a combination of that unit with today's communications terminals and RS-232-ready lap computers evolves, a hip packet system would be a snap. Only three items—all carried on a belt—would be needed: a 2-meter transceiver, a small TNC, and the computer terminal. We're already two-thirds of the way to that goal. Meanwhile, there's an interesting alternative at our disposal. It's a compromise, but it's still quite intriguing.

When copied off the air with a 2-meter FM transceiver, packet radio signals are merely audio tones. They can be recorded on an ordinary cassette recorder and later played back by directing those tones to a TNC's audio input. The only critical consideration is good tape speed regulation in the cassette recorder. Looking closer at that situation we find several popular manufacturers offer pocket-size microcassette recorders with external audio input and output connectors. Interconnect a handheld talkie and voilá, a packet recording setup that easily fits in two coat pockets. The items described in this concept are shown in Figure 10-4. The setup is easily carried anywhere, even through airport terminals. Packet activities can be monitored anywhere, then the taped message played back after returning home (or to a new friend's packet setup). It's a great way for busy travelers to learn what packeteers in other areas of the country are doing in the packet game. Some enterprising operators might even devise their own self-connect cassettes to use with this idea for passing their own information along while visiting other areas. Two cassettes might be allocated to receive and two cassettes prerecorded with transmit information. Now who'll be the first packeteer to operate from a hot air balloon or bicycle?

When selecting a microcassette recorder for pocket packet use, consider only those units with a capstan drive. A few of the super small units use rim drive on cassette reels. Their poor speed regulation is adequate for voice recordings, but not for packet use. A quick look inside the recorder's cassette area will reveal a small rubber pinch roller on capstan drive recorders. Manufacturers of suitable pocket recorders include Panasonic, Sony, and Radio Shack. Typical prices range from $49 to $150. The units are also great for recording conference talks and business notes.

Figure 10-4. The basic ingredients of a receive-only pocket packet setup.

Portable Computers, TNCs, and Amateur Transceivers

At this point, questions concerning portable packet typically center around present equipment choices and the criteria for selection. Surveying such items and contemplating purchases are always enjoyable, so settle back and we'll scan the portable market as of late-1986.

Radio Shack's lap computers—the Model 100 and its successor, the Model 102—continue to enjoy the popularity spotlight because of their shopping mall availability and occasional special sale pricings. As illustrated in Figure 10-5, their compact size is achieved by reducing cabinet dimensions and placing computer circuitry beneath its standard-size keyboard. A 40-character by 8-line LCD readout is included in the computer's upper section. It's less than a full video monitor display, true, but it's quite ample for amateur radio applications. The unit includes 32K of ROM and 24K of RAM that's also expandable to 32K. The computer is powered by four penlight size 1.5-volt batteries (an AC adapter is optional).

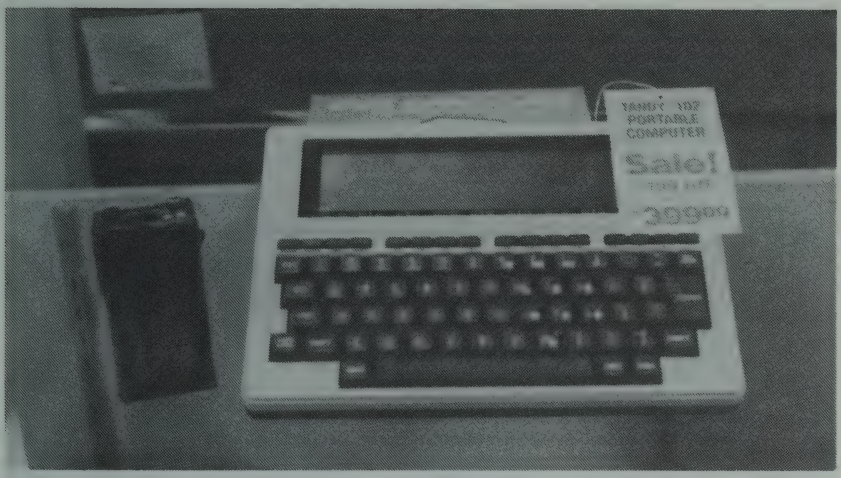


Figure 10-5. Radio Shack's Model 102 lap computer.

Packet-attractive features of the 100/102 computer include its built-in communications terminal program and direct connect RS-232 socket. These assets solve the two major entanglements associated with any personal computer, and allow for easy hookup with amateur equipment. Indeed, an all-mode interface, such as AEA's PK-232 discussed in Chapter 5, adds CW and RTTY (plus packet) capabilities to the 100/102 computer. Simply interconnect with the TNC, initialize the packet parameters, and enjoy the action. Additional basic style programs for word processing, telephone files, and appointment recordkeeping are included in the 100/102, while optional peripherals include a printer, 3½-inch disk drive, and video interface.

A recent expansion of the 100/102 is the Radio Shack model 200 (see Figure 10-6). In addition to the 100's features, it includes 72K of ROM and 24K of RAM (expandable to 72K), telephone autodialer, and a fold down 40-character by 16-line LCD screen. Check with your local Tandy/Radio Shacks for more information.

A number of unusual brand and/or surplus portable computers are often advertised in amateur magazines, and their prices are usually quite appealing. Whether such units are suitable for dumb-terminal use in a portable packet setup depends on their RS-232 compatibility, the availability (and size) of such adapters, the amount of additional internal programming that's required for dedicated use, and the number of steps necessary to turn them into a true dumb terminal. Every case is different, so get the facts, and learn what you're buying before purchasing.

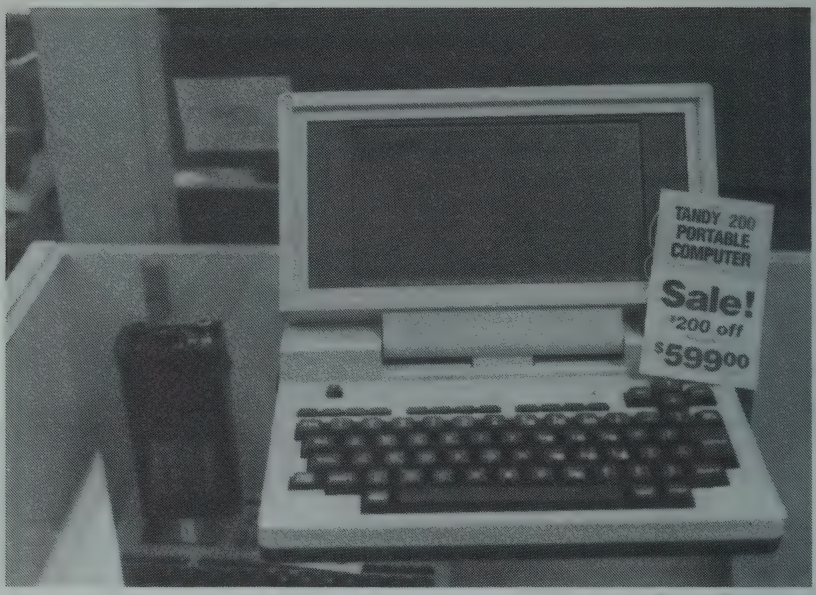


Figure 10-6. The Radio Shack Model 200 lap computer.

IBM released the first formal announcement of their convertible portable computer while this book approached completion. At that time, specific information on its packet radio features was not available. The unit bears watching, however, especially if low-priced clones soon hit the market.

While any TNC that can be powered by a 12-volt battery can be pressed into portable packet use, it's naturally preferable to use a unit specifically designed for that purpose. An especially outstanding unit in that category is GLB's miniature but full-featured PK1-L TNC shown in Figure 10-7. The unit measures only 1″ × 5.9″ × 4.6″ (H,W,D) and is powered by any 9- to 15-volt DC source. Its low 25 mA current drain makes it ideal for small 9-volt battery operation.

As shown in Figure 10-8, all of the PK1-L's circuitry is contained on a single PC board. It includes 8K of lithium battery-backed RAM, "watchdog" timers to avoid unattended lockup, and its operating commands are identical to those of the PK-1 discussed in Chapter 5. All external connections (to computer, FM transceiver, and battery) are through two DB 25 plugs and jacks mounted on the board (to avoid cross connections also). Cabling the PK1-L to other equipment is a snap, and this little gem has proven its merit

in portable setups and remote digipeater applications coast to coast. The manufacturer's address is GLB Electronics, Inc., 151 Commerce Parkway, Buffalo, NY 14224.

Figure 10-7. GLB's miniature and full-featured TNC for portable packet operation.
(Courtesy GLB Electronics, Inc.)

The area of portable VHF transceivers is a fascinating and constantly expanding world within itself. At least once a year, new and more feature-packed handheld units are introduced by manufacturers, creating a kaleidoscope of new and used units ready to move into eagerly awaiting hands. A full discussion of handheld and portable transceivers would obviously become a small book, so we'll just point out their major features and packet interfacing considerations.

The first versions of portable transceivers were relatively large and crystal-controlled units. Their RF output was nominally 1 to 2 watts, and their general performance was good. The next innovation brought smaller size and frequency-synthesized units. These impressive performers continue to enjoy great popularity. The latest innovation in handheld transceivers is the micro units. They're slightly larger than a pack of cigarettes, easily fit in a shirt pocket, and include such special features as autopatch/telephone DTMF (dual-tone multifrequency) dialing and extended frequency coverage. One popular unit is shown in Figure 10-9. The most recent units even include tuning of 2-meters, 150 MHz public service band, and NOAA weather channels in the 162 MHz band. It's truly an amateur radio wonderland. Everyone should have at least one handheld transceiver to enjoy.

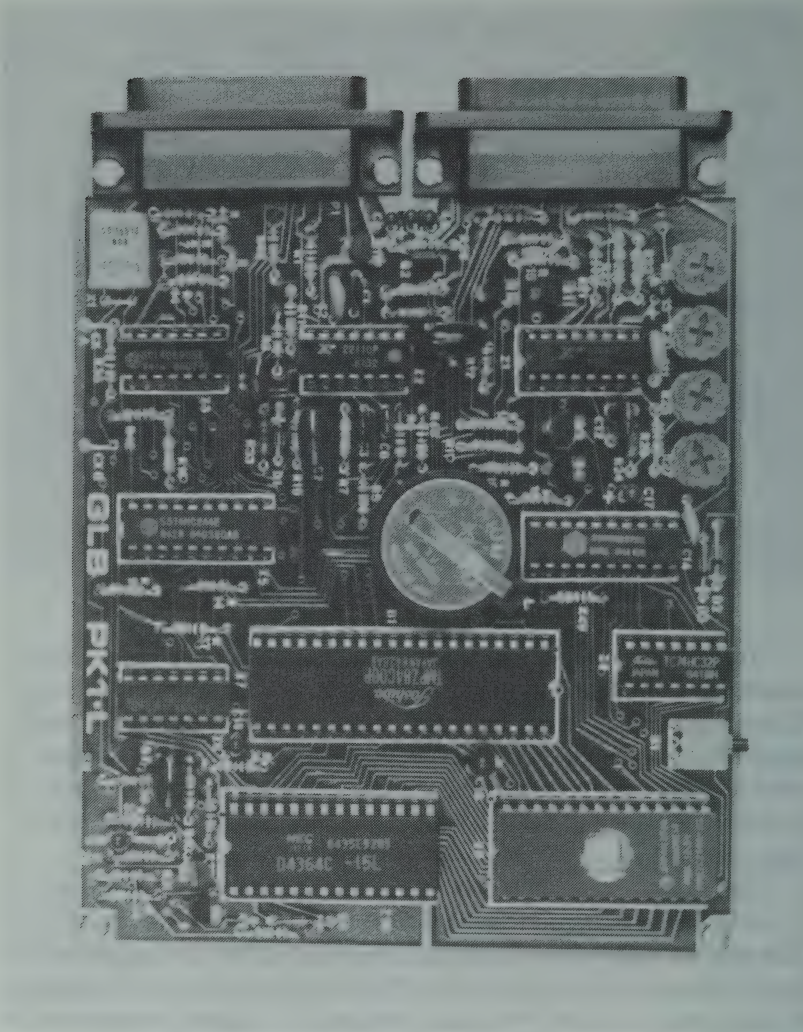


Figure 10-8. Internal view of the GLB PK1-L battery-powered portable TNC.
(Courtesy GLB Electronics, Inc.)

When selecting a portable VHF transceiver, consider its flexibilities for both stand-alone and packet use, and its supporting accessories. Standard sockets and connectors for external audio input and output are most important. Otherwise, you'll be limited to acoustic coupling, that is, holding an

Figure 10-9. The Kenwood TH-21AT 2-meter handheld FM transceiver.

audio modem to the transceiver's speaker and mike areas. An included DTMF pad is another vital consideration. Portable telephone capabilities during an emergency are an absolute blessing. Finally, consider the availability of a unit's supporting accessories. Extra clips on battery packs and rapid chargers always come in handy. No one wants to be caught with their batteries down during a time of need.

The area of portable amateur gear and packet radio equipment is continuously expanding. As the recently introduced Novice enhancement program gains a foothold and packet radio continues growing, even more exciting units will appear. We thus suggest reviewing recent amateur radio magazines for the latest news on portable packet and amateur equipment.

Summary

Portable packet systems could easily become today's hottest items simply because we're a very mobile society. Portability provides the advantage of carrying a complete communications system capable of handling extensive traffic flow into emergency areas. A briefcase packet system goes where you go, and is available anytime it's needed. A portable system also makes for the ideal message drop arrangement for busy or traveling amateurs.

If you really want to enjoy portable packet supreme, we heartily recommend adding a second carry bag or briefcase with OSCAR satellite gear. Our flying mailbox, JO-12, offers unlimited capabilities and its low circular orbit is perfect for small equipment/bush setup type use. Single unit gain/nondirectional antennas can be used if a GaAsFET receive preamp and a 75-watt 2-meter RF amplifier are included with the portable rigs, or bare handheld transceivers can be mated with beam antennas for similar results.

Our present amateur radio market offers a fascinating array of portable and handheld FM transceivers, and they all perform admirably. Whether specifically purchased for packet or general amateur use, they're a very reasonable investment. Portable and miniature TNCs were only beginning to climb in widespread popularity while this book was being written, but rest assured competition will soon become quite keen. We're already seeing signs of major manufacturers joining the portable computer game, which indicates portable packet will soon experience massive growth. Five years hence, wrist transceivers and belt-strapped terminals with built-in TNCs may liberate all amateurs from conventional home setups.

Packet Radio Tomorrow: A Look Ahead

While the current status of packet radio is quite impressive in its overall scope, its future evolutions and interactions with other amateur radio areas are even more interesting and exciting. There's no limit to the possibilities, and the journey promises to be absolutely phenomenal. Packet itself is already introducing a change in our attitudes regarding communications, and that change opens some intriguing new doors of study. Through packet radio, more emphasis is placed on the actual communicated information than the medium of that communication. In other words, the communication can be changed in speed and operating frequency or even stored for a variable amount of time before reaching its destination while the actual information is transferred with maximum efficiency. In some ways, this might be analogized with cross-country traveling via different vehicles. We could drive an open convertible from Florida to California and thoroughly enjoy our land's beautiful scenes and natural wonders, or we could make that same trip in an aisle seat of a night flight airplane . . . or a train . . . or even in an enclosed box. Either way, we ultimately arrive at our destination. The only remaining question is what was our original purpose—enjoyable traveling or enjoyable activities at our destination. Conventional HF voice communications reflect the former choice while packet radio reflects the latter. One is more efficient; one is more fun-filled. Both survive, and both fill a definite niche in our society. Having double enjoyment at our disposal, however, simply makes life one notch better. Personally, I feel (and hope) the classic pursuit of HF DXing—of riding the waves of ether like a skilled acrobat—will always continue, but it will also be backed up by predictable secondary media if and when needed.

It's often possible to study past evolutions, visualize their logical path of progression to the present, then use that insight to make an extrapolation

of probable future developments. As we take that attitude with packet radio's future, some fascinating concepts start to become visible. Likewise, the obvious step-by-step progressions leading to tomorrow are taking shape at the present time.

As packet's major networks continue expanding and providing coverage of more and more areas, we continuously move closer to a national and internationally linked system that's completely reliable. Likewise, the demands for efficiently handling increasing amounts of traffic grow with such a system's evolution. Three interesting considerations immediately come to mind. One involves increasing the number of paths in the same direction similar to the way we increase freeway lanes to handle traffic. Another suggests increasing data flow rates on main paths with local area off-ramps returning related data to normal area speeds. A third consideration would involve using intelligent digipeaters and switch-type concepts such as those incorporated into large telephone systems. Again, it's only logical to surmise that future evolving systems will use a combination of those concepts along with a few more ideas that will evolve further down the line.

The first prototypes of these high-volume networks are moving toward reality at the present time. Some U.S. areas are beginning to use statewide 9600-baud trunks on the 220 MHz band for moving interarea traffic. Community ports interface local area 1200-baud traffic with the 9600-baud trunks. End users operate their packet systems in a normal manner; indeed, they do not even need to be aware of data rate changes to reap the benefits of accelerated communications. A simple 9600/1200 baud and 220 MHz to 145 MHz interface similarly provides direct compatibility with other existing networks, and allows each geographical area to advance at its own pace.

Another concept that's also moving toward reality at this time involves intelligent TNCs or switches that connect with each other to move traffic in a highly efficient operating manner while outputting only pertinent information to end users. Once again, those users are not required to understand interswitch operations, but merely how to connect with switches. Evolutions are handled on what we might call an upper level, but user and adjacent network compatibility is maintained.

Gazing farther out on the horizon, we see the future launch of three geostationary OSCAR satellites opening a new era of completely reliable worldwide packet and voice communications. This Phase IV project was originally scheduled for implementation before the end of this decade. There's still a good possibility of that becoming reality, but recent setbacks in the

U.S. space programs are placing a premium on future launches. The situation might be compared with airplanes waiting in line on a closed airport's runway. After the fog dissipates, things again begin to move according to priorities. The Phase IV concept involves placing three very sophisticated OSCARs high above the earth's three major oceans and interlinking them via ground relay stations. A further discussion of the Phase IV project is included later in this chapter.

Continuing our future views, we see pocket-size data terminals and mated packet systems interfacing with main area digipeaters and switches in a remote base manner. This evolution could completely eliminate the home setup concept, and all the gear would instead fit into a coat pocket yet provide worldwide range anytime or anywhere. Networks, electronic mailboxes, OSCAR satellites and even digitized audio (and video) blend into one all-encompassing system. Microwave frequencies are used extensively, as their massive bandwidths handle vast amounts of traffic at phenomenal speeds. The high frequency bands have become a classic and nostalgic area with enthusiastic "old timers" still proving that riding the waves of ether takes a lot of skill and can be immensely enjoyable. New amateurs listen to the old timers and wonder, could they actually have a point? Maybe there is more fun and skill involved in playing the ionosphere game on HF bands. Maybe it would be worth pursuing. Let's see . . . if we can find some older shortwave transceiver and maybe some toroids and wire for antennas to home-assemble a genuine authentic setup . . . my gosh, gang . . . we're living in the Golden Age of Radio right now!

The Level III Concept

As this book is being written, the AX.25 protocol is in its second version or level or modification. It's only natural to assume that additional modifications and levels will follow. Predicting exactly when such evolutions will take place may be guesswork, but they will take place. Of course, the prime consideration of maintaining compatibility with existing systems always plays a significant role. Fifty thousand end users can't simply be ignored or given thirty days to get new gear.

Evidence of the development of AX.25 version 3 (or level 3) was beginning to surface during late-1986. The concept involved using intelligent microprocessor-based systems at digipeater sights and creating an overall intelligent data network as opposed to the passive design used in level 2.

Under the level 3 concept, a packet station will initially CONNect with its local area "switch" (term for level 3 digipeater) rather than CONNecting with a desired distant packet station. The switch will then act as an intermediate or middleman, taking input from the first packeteer and forwarding that information through the network to the other packeteer (or packeteers, depending on the desired CONNection). The arrangement offers several distinct advantages. Since transmitted packets will immediately be accepted and ACKnowledged by the inputting network switch, end user systems will be free to prepare and evaluate other text or conduct additional QSOs. The immediate ACK from the switch also avoids multiple RETRYS going from one end to the other of the network, and consequently reducing everyone's throughput. Packets then move between switches with NACKs being limited to only those points of major congestion, while the rest of the network continues to operate at maximum throughput. Meanwhile, the level 3 user sits back, confident that his or her message *will* get through in the shortest time.

Because level 3 packeting might be compared with turning messages over to a delivery system, it's also open to numerous future expansions while again maintaining compatibility with end users. The intelligent network, for example, can diversify traffic among various high-speed trunks on additional bands, or even shift data to wideband microwave frequencies. Satellite and HF gateways can be called into use as needed; even teleconferencing among various areas of the world can be implemented with ease . . . and all these capabilities will be available to end users operating simple systems that can go anywhere. Yes, we're moving amazingly close to that fascinating time when worldwide communications will be accessible anytime and/or anywhere. One of the major innovations that will also play a significant role in this future style of radio involves expansions in our OSCAR satellite program. The continuing progression in this direction is both imminent and logical. Satellites operate independently of sunspot variations, they are reliable, and they utilize upper frequency bands to maximum advantage. Let's now take a closer look in that direction.

Evolutions in the Amateur Satellite Program

Considering the close interrelations between OSCARs and communications, it's quite obvious that future evolutions in our amateur satellite program can directly influence packet radio. Both media are spectrum and efficiency conscious, both utilize upper frequency bands, and both reflect waves of future progressions.

The first amateur satellite to endorse packet communications was OSCAR 10, and the joint venture proved to be highly beneficial. Next, JO-12 carried a special digital transponder especially designed for flying mailbox operations. That satellite's packet radio success was also overwhelming, indicating a definite interrelation guaranteed to expand as time progresses. Today, we look forward to the upcoming evolution of Phase IV OSCARs and the unbelievable new world they're destined to open.

The Phase IV concept is presently slated for implementation during 1989. A spectacular triple launch is planned, with the three super elaborate satellites assuming positions high above the Pacific, Atlantic, and Indian Oceans. Through the use of specific frequency selection and earth-based satellite interlinks, operators will be able to direct signals east or west of a location to communicate with specific world areas. The planned bands of operation are 23-cm, 70-cm, and 2-meters, and the planned modes include everything from SSB and CW to packet radio and digital audio or video concepts. An overview of this system is shown in Figure 11-1.

Basically, the planned Phase IV concept will operate in the following manner. Let's say you live in the mid-U.S. area and wish to communicate with a Far East area such as Japan. You beam signals toward the Pacific area satellite using its center or direct range passband for single satellite relaying. Communications are quickly and reliably established using that satellite located approximately 20,000 miles above Hawaii. If you desire to extend those communications into the India or Pakistan areas, you shift operations into the lower range of the satellite's passband. That change will call up the Indian Ocean's satellite through an earth-based interlink and repeat your signals in a double relay manner. If you prefer communicating with Europe, however, you swing your beam east and operate through the Atlantic Ocean's satellite using its middle or direct range passband area. Likewise, you could shift to that transponder's upper range and double relay through the Indian Ocean's satellite as well. Fantastic concept, don't you agree?

Looking closer at the Phase IV concept, we also recognize its benefits and advantages for broadcasting important messages and bulletins to the whole world in real time. This capability could be utilized from any area, and it would prove to be invaluable during emergencies, for announcing major events and their results, etc. A planned mailbox and BBS will further enhance those capabilities and provide access any time to pertinent information. Teleconferencing, both nationally and internationally, will also be a major Phase IV capability. In fact, the many planned Phase IV capabilities will undoubtedly cause amateurs and SWLers alike to scurry for basic equipment

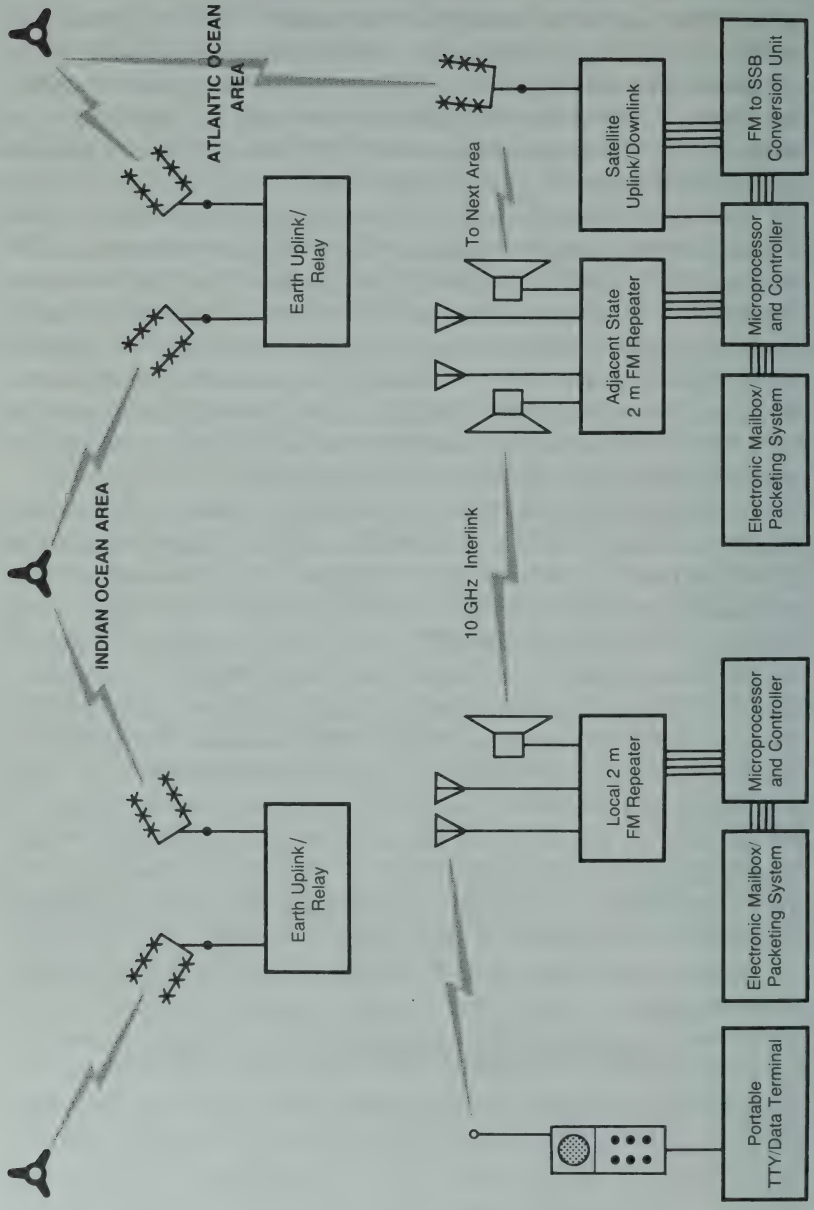


Figure 11-1. Overview of OSCAR Phase IV concept.

for surveying the action. We can also look forward to satellite gateways, interlinked repeaters, and large terrestrial mailbox setups. Handheld transceivers and portable terminals linking into the system will then truly be in the mainstream of action, and the excitement is only beginning. Voice digitizing concepts and FM/SSB converters (both of which are under development and moving closer and closer to reality each day) will combine the many areas of pursuit into one totally deluxe system.

As this book is being written, indications of an OSCAR Phase V are slowly developing on the far horizon. While the picture is currently cloudy, some aspects appear to be clearly imminent. A wideband multichannel digital and analog relay unit is being planned for installation in the U.S. space station. That launch is expected to be between 1989 and 1992. A similar relaying unit is being planned for installation on the moon. Meanwhile, discussions continue concerning digital video concepts for integration into future space telescopes.

Our future is truly unlimited, and OSCAR satellites along with packet radio concepts will play a significant role in that future. The technology is here today; we need only to prove our beneficial use of the medium, and packeteers are the ideal candidates for providing that proof.

Digital Audio and Video

As all packeteers will surely agree, the concepts of digitization have made a definite impact on modern society. This revolution initially influenced printed word media, then it began propagating into the audio and video worlds. Today, almost every communications medium in existence is being affected by the digital revolution. It's only logical to assume that the expansion and widespread adoption of digital audio and video will soon share the packet radio spotlight.

The basic technique of converting an analog signal to its digital/binary equivalent is illustrated in Figure 11-2. In the example of the television signal, sync tips are considered as zero volts or binary count zero. Black would thus be a hypothetical half volt, white would be 5 volts, and greys would be various levels between those values. Through the use of time-gated, sample-and-hold, and analog-to-digital converter circuits, specific counts can be established for each minute voltage variation. The resolution or definition of that conversion is directly affected by the number of samples taken during a specific period. The greater the number of samples (and

related digital counts), the more defined or near perfect replica the digital signal becomes. Audio signals can likewise be digitized, and the resultant information can be handled in all the popular computer-based ways. It can be stored in RAM or ROM, manipulated, accelerated or decelerated, even placed in an electronic mailbox or bulletin board system for later access by others.

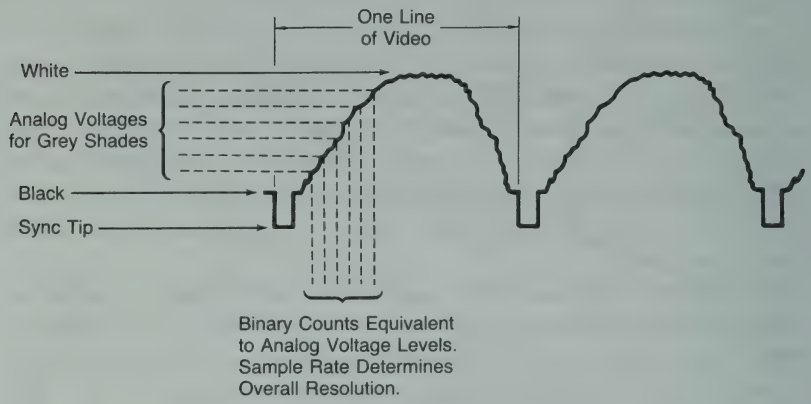


Figure 11-2. Basic concept involved with converting an analog television signal to its digital/binary equivalent.

Digital audio techniques and applications in industry are already making significant strides. Some developments such as digital music compact disks, are well-known; some are more subtle. A commercial audio mailbox system utilizing completely digital techniques is employed for several businesses in the Midwest. It functions exactly like a packet-type mailbox, except it's accessed by telephone voice. Messages and bulletins can be stored, read, even forwarded to other similar systems using high baud rates. Adapting similar concepts to the world of packet radio is our logical next step, and that progression could easily happen soon. Imagine the capability of accessing a voice mailbox (or maybe a voice-to-packet converter), moving that information in 400-plus word-per-minute bursts around the world via interlinked satellites, and you'll agree amateur radio's future world is indeed fascinating.

The story doesn't end here, however. Digitized video (which is already being used on a daily basis by slow-scan TV operators around the world) opens yet another area of applications. Complete and personalized views of the people we contact can also be condensed into high-speed bursts and communicated in a packet manner. Assuming sufficient memory and video

interfacing are available as add-on units to portable packet systems, one only needs to add a small camera and TV monitor to create an ultimate audio/video/printed word portable communications system. Taking all this into consideration, we can only conclude that packet radio is truly the wave of the future with an unlimited number of applications and areas of interests for today's amateurs. As this book has pointed out, the time to get cracking in packet radio is now. Go for it, and we will be looking for you on packet soon.

[A closing note from author Dave Ingram, K4TWJ.] Need a particular question answered or a little help getting started? Although my schedule is quite hectic and my numerous areas of pursuit easily overfill a 24-hour day or seven-day week, I always strive to help others through direct QSOs on the air. I frequent 14.180 to 14.205 MHz (depending on QRM) most Sundays and many Saturdays between 2230 and 2330 GMT, talking with amateurs like yourself on every topic imaginable . . . from OSCAR and packet to radio astronomy, restoring vintage gear, DXing, understanding modern gear, collecting keys, and much more. Letters are flawed, what with SASEs, time to travel, answer and return, but on-the-air conversations are real time results. Give us a call, and we'll do all we can to help you. Favorable comments are also always welcome!

Summary

The world of packet radio is new and young, but it's already being refined into a powerful and easy-to-use communications tool. We haven't seen anything yet, however—the most exciting times lie ahead. Each day, the future moves closer to reality. Smaller and more powerful computer-based systems continue evolving. Amateur radio gear also continues to become more sophisticated and compact. Meanwhile, networks and networking concepts are expanding into higher levels of operation and amateur satellites continue to increase our communications capabilities tenfold.

We are moving closer and closer to that magic date when our separate media will combine into one overall ultimate setup. FM/SSB converters are only one side of that fascinating picture. Digitized audio and video will provide full compatibility between all media in truly unique ways. Voices, pictures and printed words can be intermixed and converted in a universal manner. Full digitization will also open many doors to high speed, high

density communications, their reliable and predictable worldwide propagation being provided by OSCAR satellites.

Looking further down the exciting road ahead, we can also visualize holographic video concepts filtering into amateur communications through digitizing and packeting techniques. Holographics require scanned laser beams plus an extensive amount of data storage for image re-creations. One means of achieving that capability involves using wideband signals, namely microwaves. An attractive alternative, however, involves high density-packetizing its digitized equivalent information, and moving that data at high speeds over conventional channels. Packet radio's future will surely include some fascinating spinoffs!

Might there be even more evolutions during the twenty-first century? Sure . . . progress is eternal! Refinements in holographic video systems, for example, will again open new doors. One of those new areas will surely include electronic transportation—synthesized at first, but later developing into the real thing. As we then begin to study propagation delays and distances, visions of time travel (only forward) begin to evolve. Distances measured in light years have a different reference than time on earth. Using that futuristic reference, we can also visualize the evolution of a totally new form of communications during the twenty-first century. Such a revolutionary concept would not employ any form of electromagnetic radiation, and thus would not be detectable by any of our presently existing types of equipment. There are currently several interesting areas ready for pioneering (such as isotropic elements and Beta forces), but the cost of experimentation and development is far beyond that available to individual laboratories. Amateur radio is thus ensured of a long and fascinating life that should continue well beyond our lives. Enjoy. We're living in a Golden Age of Radio when each day is a dream come true and a beautiful memory tomorrow!

Glossary

ACK—Acknowledgment of error-free copy from the receiving station to the transmitting station.

ASCII—Acronym for American Standard Code for Information Interchange. An internal language of computers and data communication systems.

Baud ***(rate)***—The speed or rate of data communications, usually in bits per second with four bits equalling one baud.

Beacon—An unconnected and general public-type of message transmitted at some preset interval. Was useful during early days of packet when few operators were on the air.

Connected—When two or more packet stations are conducting a communication, they are said to be "connected" . . . similar to visualizing a wire or telephone connection.

CPU—Central Processing Unit. The main brain or heart of a computer. Often supported by co-processors. The CPU controls data flow and manipulation into, from, and within a computer.

Digipeater—A digital repeater used for relaying packet radiocommunications. Consists of radio, TNC, and memory. Any packet station can also function as a digipeater.

Elliptical ***(orbit)***—An OSCAR orbit that moves a satellite thousands of miles into space, then makes a rapid swing around the world with the cycle then repeating.

FSK—Frequency-shift keying. The mode used for HF packet communications, usually with a 200 Hz shift.

Gateway—An on/off point for changing carrier or communications media for packet (and other) communications. One example is an HF gateway—VHF packets move through the gateway and onto HF bands. A kindhearted amateur is behind every gateway setup.

HDLC—High-level-data-link controller. A special microprocessor used in packet radio systems. It helps format, assemble frames, and check transmitted and received packets.

Geostationary *(orbit)*—An OSCAR orbit that tracks with or follows the earth's rotation so it always appears at a fixed point in the sky.

LAN—Local area network. A group of packeteers in the same area using one digipeater and operating on the same frequency.

Modem—A data communications MOdulator/DEModulator unit. Inputs voltages, outputs tones, and vice-versa.

NOVRAM—A special form of nonvolatile random access memory that retains its memory when power is removed. Used in several TNCs.

OSCAR—Acronym for orbital satellite carrying amateur radio. An ongoing program since 1961 that has supported over a dozen dedicated amateur satellites.

PAD—Packet assembler/disassembler. The original term given to a TNC. It assembles/disassembles packets of information and directs related data to its respective areas in a packet system. The term will take on new meaning with the advent of level 3 protocols.

Protocol—An established set of parameters that must be used by all operators playing the game. A means of defining various aspects used in packet's inner operations.

PROM—Programmable read-only memory. Used in TNCs to store owner-programmed data such as call signs.

RAM—Random access memory. The working memory and continuously changing section of a microcomputer.

ROM—Read only memory. The fixed bank of information which a microcomputer uses for reference during operation.

Throughput—The actual or overall rate of how fast and effectively packet communications move through a packet network (from input to output). It's influenced by data speeds, number of simultaneous users, packet collisions, multiple repeats, etc.

TNC—Terminal node controller. The unit connected between an amateur transceiver and home computer for packet communications. It contains both modem and data-manipulating sections. An intelligent interface.

WAN—Wide area network. A packet network covering a large geographic area. A large area digipeater or several linked digipeaters are usually included in a WAN.

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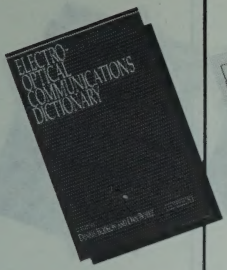

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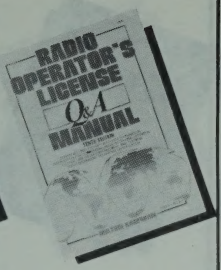

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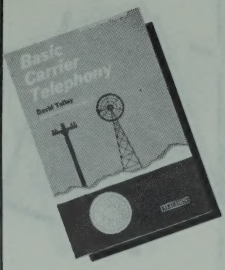

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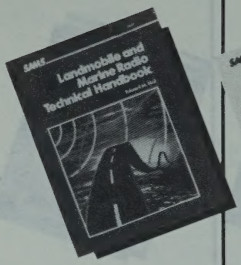

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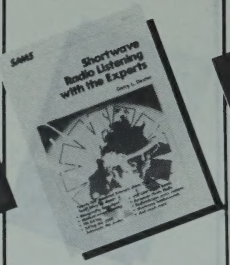

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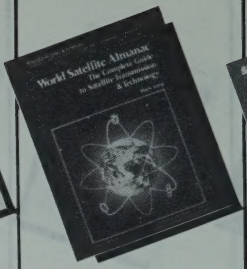

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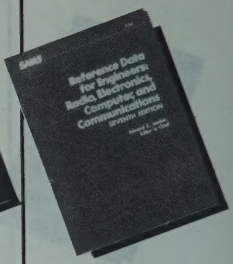

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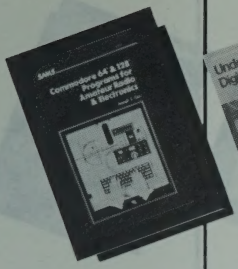

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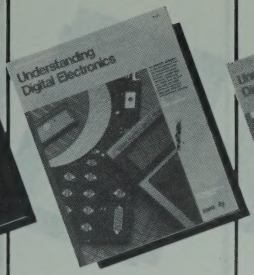

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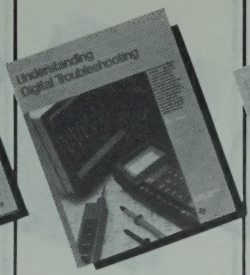

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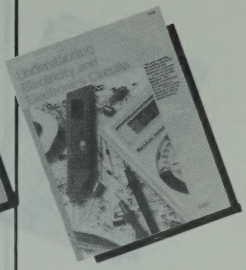

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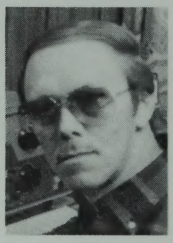

Dave Ingram, K4TWJ, has written more than 300 articles for amateur radio magazines, authored twelve published books on amateur radio, and has taught college electronics for over 10 years. An amateur radio enthusiast for more than 25 years, Mr. Ingram is known and respected worldwide by the amateur radio community. He holds First-Class Radiotelephone (with radar endorsement) and Amateur Extra-Class licenses.

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